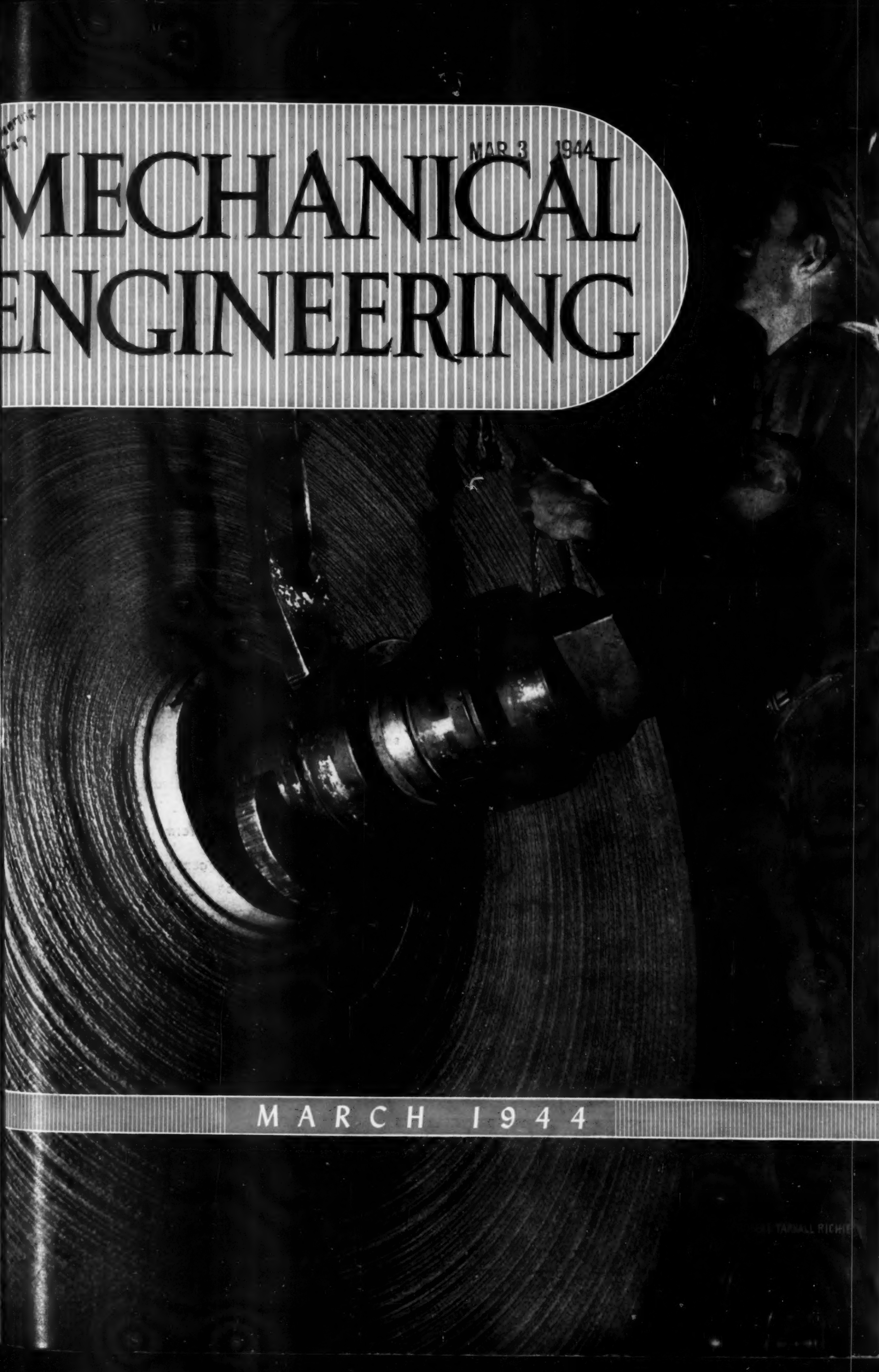
MECHANICAL ENGINEERING



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MECHANICAL ENGINEERING

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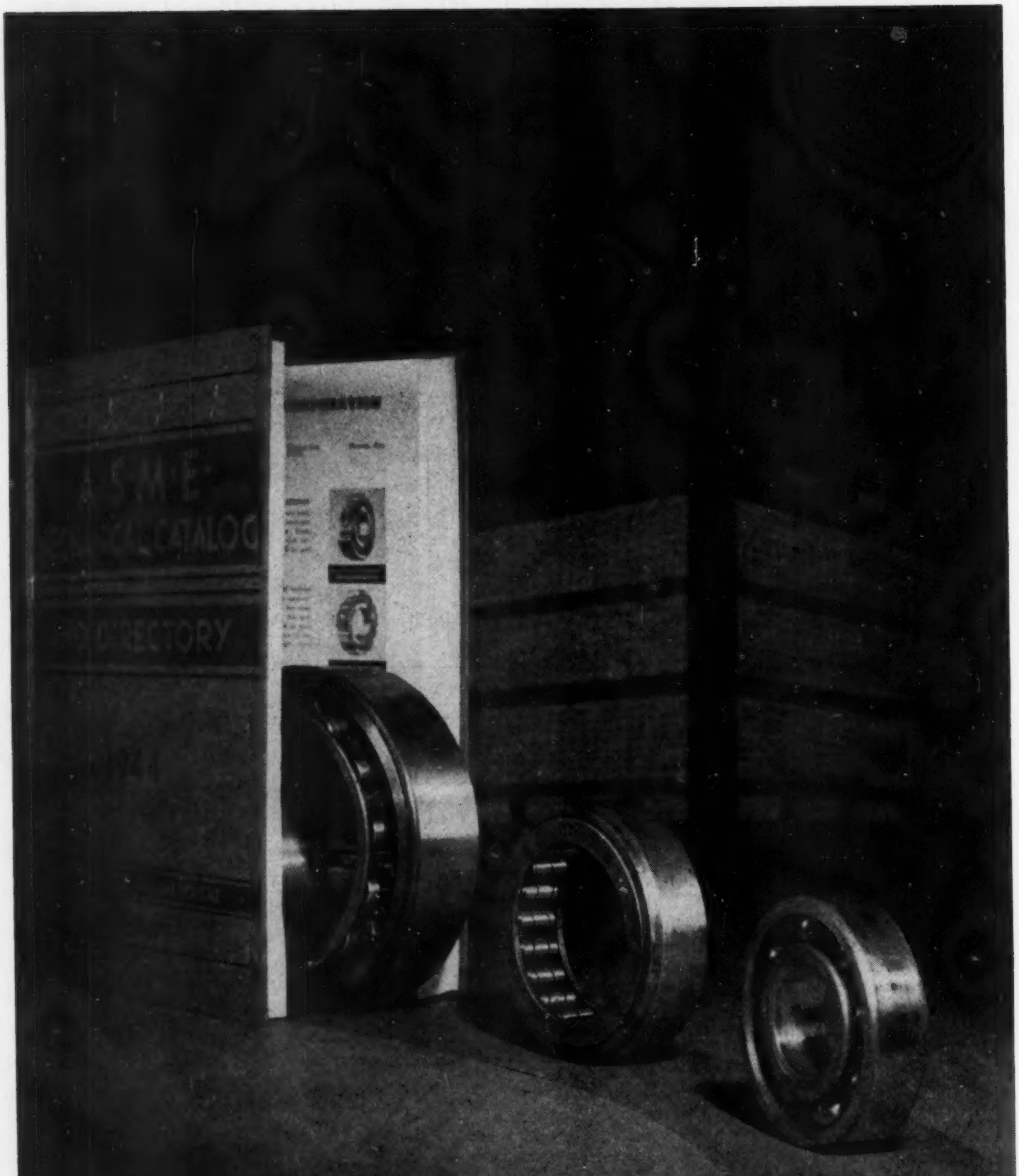

J. Mack Tucker

Industry Does It

Volume 66
No. 3

MECHANICAL ENGINEERING

March
1944

GEORGE A. STETSON, *Editor*

8000 Jobs for Engineers

FROM Census figures the authors of an article on engineered distribution techniques, published in this issue, estimate that there are 8000 potential jobs for engineers in this rather generally neglected field.

Certainly, 8000 jobs for engineers are not to be dismissed lightly when the postwar period brings us face to face with the grave problem of maintaining a high level of employment.

But these 8000 jobs constitute only one portion of the benefits that may be derived from a thoroughgoing engineering approach to a neglected field. Out of the "fifty-nine cents on the dollar" distribution costs which the nation now pays, there is to be found not only the money to hire these 8000 engineers but also the dividend of lower prices paid by purchasers. This dividend is potential purchasing power for additional goods and services, to provide which additional employment and business activity will be in demand.

Nothing new is revealed by the authors of the article referred to. Nor is there any misconception on their part that engineers have made no contribution to the complex problem of distribution. Far from it.

What is presented by them is a condensed summary of some practices in the field of distribution that have been proved to be successful in lowering distribution costs and building up enterprises and profits. As stated at the end of the article, the literature of the subject already examined has uncovered more than 2000 cases. The authors' examples number twelve only, but each illustrates some fundamental principle that has almost universal application.

If 2000 case histories have been turned up so far, why is it that so little total effect has been felt in the lowering of distribution costs? The reasons are not far to seek. In the first place, the number is pitifully small as compared with the total number of enterprises to which the principles might be applied. Moreover, the authors have found that, generally speaking, companies have followed one of these principles with conspicuous success; few have put in practice more than one, even if others could be applied profitably to them.

Most conspicuous of all, however, is the fact that the field of distribution itself has not been broadly subjected to study under approved engineering principles of analysis and determination of policies of procedure that have been so successful, since Taylor's day, in the field of production. For the revolution in the technique of management set off by Taylor and his contemporaries affected principally the production phase of business enterprises. Here it was that engineers, whose habits of thought and work were attuned to Taylor's methods, were most universally employed. The engineer in the shop, even if he gave to management techniques no greater status than that of common sense, could understand what the management engineers were talking about, could analyze and weigh new methods, and could evaluate results. This he can also do in the field of distribution when he brings to the task the same methods that were employed in increasing the efficiency of production.

The 8000 engineers who may conceivably find jobs in the distribution field will not cultivate it as salesmen. Their task is to lay the groundwork, by utilizing their methods of work and their knowledge of industry and its requirements, on which will be based the policies of corporations, large and small, in increasing the efficiency of the distribution process.

Awareness of engineers to the potential value to themselves and to society of greater efficiency in the distribution process and the capacity and enthusiasm to tackle the job are not enough. The entire corporation must be fired with an equal zeal and must co-ordinate all its departments to help attain the goal. What price a fraction of a cent saved by an improvement in production technique if dollars are wasted in distribution? As the authors say: "The next great test awaiting business is its ability to bring its scientific knowledge of distribution up to the level of its scientific knowledge of production." Engineers cannot do this job alone; but they have the ability to do for distribution what they have done for production. The task requires the engineering method of approach. Here again the engineer is the man who can do for one dollar what any one else can do for two.

Problem of Unemployment

THERE is no doubt in the minds of most of us that employment will be our biggest and most important postwar task. The problems which we did not solve prior to the war will arise to plague us again, unless positive and intelligent plans are laid well in advance of the actual occurrence.

Some months ago one of the regular reviews provided by the members of the Department of Economics and Social Science at M.I.T. discussed certain plans for the future that have been put forward in Great Britain and the United States—the Beveridge plan and the National Resources Planning Board plan.

That some plan, whose details and name are now unknown, will be adopted as a matter of public policy by the great democracies is scarcely to be doubted. What must concern us is that the plan adopted shall be a workable one. To assure that it shall be so, intelligent men and women must do a lot of hard and painful think-

ing of the variety known as straight and must not allow themselves to become obstinate, complacent, or unimaginative.

As a preface to this process of self-education many articles, pamphlets, and books are available. What time busy people can spare from the immediate concerns of the present should be spent thoughtfully and critically with current discussions. Among these a little pamphlet, "The Problem of Unemployment," prepared by the directors of Lever Brothers and Unilever Limited and published by the Oxford University Press, is an excellent supplement, easily read, to the exhaustive statistical studies that comprise the Beveridge report.

The pamphlet referred to appeals most directly to Canadian and British industrialists, but for that very reason it becomes easy reading for readers in the United States. One can approach the policies and problems of other nations with greater objectivity and less personal bias than arise to confuse him in the consideration of the policies and problems of his own country. Having decided that the prescription may restore our neighbors to health we may then, with less emotional bias, consider what portions of it, or what modifications in the formula, would apply to ourselves.

Extreme condensation is one of the characteristics of the pamphlet referred to, and hence further condensation of it becomes difficult. But to condense still further the "conclusions," the argument of the pamphlet "presupposes the productive capacity of the nation being used continuously and without restrictions from either the side of manufacturers or that of labor" to "provide those consumer goods that are necessary to give everybody decent housing, decent food, decent clothing, and those amenities of life that make up modern civilization. Side by side with this, productive capacity must provide for its own extension."

Inequality of employment is seen as an irregularity in production activities. The problem of unemployment is thus seen to depend on the problem of keeping extensions of that equipment regular. Although a self-imposed discipline on the part of industry can help, "the main task in fostering regular capital investment, and through it regular employment, lies with the government. This does not mean the exercise by government of direct control over production . . . . it means the exercise by government of the powerful means of indirect control it possesses."

What are these means of indirect control? Monetary policies; government investments; and budgetary policies, at present carried on with disregard for their economic effects (the two-budget policy is urged) are suggested. The corrective influences of these antislump or antiboom measures are to be brought to bear with fluctuations of the labor reserve, in both numbers and the way it is made up. "In case the effect of these general measures should not be enough, or in case unemployment be wholly or partly of a structural or incidental nature," supplementary measures—public works, special training of younger persons, retraining of work people, occupation in temporary work—are to be applied.

What industrial measures are to be taken? Antiunemployment measures, such as planning development with as long a view as possible, following at all times a policy of maximum production, voluntary schemes of training work people to assist fluidity or mobility of labor; social-security measures, such as caring for health and housing, voluntary schemes of guaranteeing earnings during sickness, accident, or temporary unemployment, and developing works councils or similar bodies for developing employees' sense of well-being of the enterprise they are engaged in and opening up possibilities of their rising to higher responsibilities; and keeping the government informed of conditions likely to affect the labor reserve and of up-to-date knowledge about production and marketing, are cited.

Lastly, are the international measures resorted to when events in other countries affect employment at home. These include: "Adapting productive capacity, dislocated by the war, to allow the various countries to produce and consume according to their abilities;" encouragement of international trade; protecting against unfair competition other countries that embark on unemployment measures and plans for social security; regulating the production of stocks and the prices of raw materials; and raising the standard of living in undeveloped countries.

Incomplete and inadequate as this fragmentary glimpse of the pamphlet is, it is hoped that interest in and close study of it and similar writings will be stimulated for whatever effect they may have in the solution of our own major postwar problem—unemployment.

Carnot Republished

FEW, if any, engineers ever forget the name of Carnot or the beautiful piece of reasoning, known as Carnot's principle, which establishes the criterion of efficiency of the heat engine. What later scientists and engineers have built upon Carnot's demonstration in establishing the Second Law of Thermodynamics and its practical and philosophical implications has only added luster to his name. Easy to understand and remember and resulting in a simple expression devoid of constants characteristic of the working substance or the working mechanism, Carnot's principle will always remain one of those flashes of genius which glorify the human mind.

In recent months The American Society of Mechanical Engineers has republished Carnot's work, "Reflections on the Motive Power of Heat" in the translation made by the Society's first president, Robert Henry Thurston. Another A.S.M.E. president, A. G. Christie, has provided a foreword to the new edition. But most unique of all is the fact that the entire book was set by hand by Robert H. Roy, member A.S.M.E., of the Waverly Press, Inc., Baltimore, whose hobby is hand composition.

Mr. Roy and the Waverly Press have produced a beautiful example of bookmaking and design which will delight anyone interested in these arts, and they have also made available to engineers one of the great classics of engineering literature. In addition to Carnot's essay and Professor Christie's foreword, the book contains Thurston's preface to the translation and a brief sketch of the life of Carnot. Altogether, the new edition is rich in engineering interest.

Some Psychological Factors Favoring INDUSTRIAL INVENTIVENESS

By ELLIOTT DUNLAP SMITH

MASTER OF SAYBROOK COLLEGE, YALE UNIVERSITY, NEW HAVEN, CONN. MEMBER A.S.M.E.

THE inventiveness needed in industry today is more than "Yankee ingenuity." The old homespun resourcefulness is still as valuable as ever, but to be useful in modern industry the inventor must be both intuitively resourceful and scientifically sound. An example will make clearer what this combination means.

Greeting cards for generations had been printed from steel dies with linseed-oil inks. Then a trend in style made it necessary to have deeper cuts in the dies to make more dramatic effects. This meant that, when the card was printed, the ink, instead of being thinly spread, was massed on the card in thick ridges. Since linseed-oil ink dries by oxidization from the air, the drying of the outer surface of ink created a skin which made the penetration of oxygen from the air to the ink inside these ridges extremely slow.

To speed up the drying, mechanical engineers devised various schemes, utilizing heat and draft, but without solving the problem. Each color that was printed still took several days to dry. Then an invention was made. Instead of working upon the problem of air-drying at all, a young man conceived the idea of using inks which would dry internally through chemical reaction and, in a short time, an ink base was developed that dried almost instantaneously regardless of the size of the ridge. As a result the cards could go on a belt directly from press to press.

This problem was clearly a technological one and the inventor had to be scientifically competent in order to deal with it. Yet the act of inventiveness which achieved the solution was not logical scientific thought at all. It was a flash of intuition which showed the problem in a new light.

INTUITION AND LOGIC BOTH ESSENTIAL

Such intuitive insight, even though scientific, differs sharply from the systematic, explicit process of logical scientific thought. The logical thinker consciously works out his solution. He does so step by step in orderly sequence. He thinks principally in words or symbols, and he can put his logic into language so that others can follow it. The intuitive thinker gets his answer unconsciously by all-at-once insight into the problem as a whole. He cannot put his process of thought into words for he is unaware of the means by which his insight came. Today the inventor must be able to do both types of thinking.

The process of creative insight has much in common with the intuitive formation of images in customary thought. For example, if a curve like this) is displayed with the statement that it is part of a whole the rest of which is concealed, most people will see the whole in their mind's eye as a circle. But some will probably see it as a segment as in Fig. 1(*a*), or as a

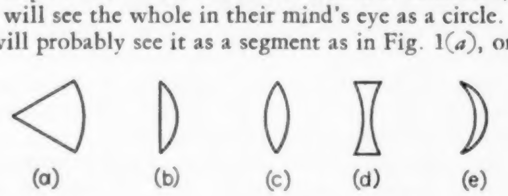

FIG. 1

What I fear most as an obstacle to inventiveness in industry is that as a young engineer pursues the long slow path of education and experience, he succumb to the past... The most important way out of this dilemma is to make education and experience more fundamental. If in school and at work the resourceful young engineer is required to shun memorized formulas and to go back to basic principles for the solution of his problems, the process of developing technical competence will in itself give him the basic understanding and way of thought essential for inventiveness. When logic thus goes back to fundamental origins, and is in that sense original, logical development and inventive insight come close together. Both make possible fundamental shifts to more profound bases of approach.

sector, Fig. 1(*b*). If, however, some of the group have been working with lenses, they might see it as one of the following lens forms, Fig. 1(*c*), (*d*), or (*e*).

Whatever the conception, rarely will it result from logical deduction. Of those who saw a circle, probably none will have plotted perpendiculars to tangents and found that they met at a point, and then having found that every point on the curve was equidistant from this focus concluded that the figure was a circle. Instead, the hint provided by the fragment caused each person to see some figure as the whole, without conscious reflection.

It is important to realize that this type of unconscious all-at-once identification permeates our daily life, and that without it we would be helpless. It is important also to realize that a single hint or clue, depending upon the angle of approach, may give rise to a wide variety of conceptions even in a single mind. This is true even when, as here, the element giving the hint is mathematically precise. Moreover, if one conception fails to satisfy, the mind can shift quickly to another.

What an inventor must do is similar to this. He must resourcefully create out of obscure clues vivid and varied configurations. If configurations of one sort fail, he must be able to view the problem from a completely different angle, such as viewing the curve fragment shown, from the point of view of lenses in case a geometrical approach fails.

Curiously, what the mind recognizes with either hints or wholes, is not the exact patterns which are formed on the eyeball but their structural form. For example, if one holds a circle first at 10 and then at 11 in. from one's eyes, the different-sized images made on the eyeball can have in common only one point of tangency or two points of intersection. Nothing more! And yet at any distance where the image is clear, and even if the sheet is viewed at an angle, no one has difficulty in seeing that the form is circular. This is even true with such complex patterns as chairs, or a person's face. Thus a child has no difficulty in recognizing its mother at different distances or angles.

Intuitive recognition occurs even when there is no common external stimulus; merely different instances of variable structural form or type. For example, there are almost no character-

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, New York, N. Y., Nov. 29–Dec. 3, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

istics common to all Jews. Yet people can ordinarily intuitively recognize a Jew, no matter in what ways he varies from type. This is of fundamental importance because it makes possible intuitive thought in regard to generalizations and abstractions. It thus enables intuition to deal with problems of abstract science.

APPLYING INTUITION SCIENTIFICALLY

There is no fundamental difference in intuitive recognition when scientific knowledge is involved. Two men, for instance, are walking in the woods. There is a flash of lighter green in the trees. One man sees nothing but a flash of lighter green. The other says "That's interesting. I have never before seen a yellow-breasted flycatcher in this part of the world." In his well-trained mind, the hints of changing color had been unconsciously associated with what he knows of the bodily structure, way of flight, and color patterns of birds, ***into a meaningful whole***, so that what he actually observed was not the flash of color noticed by his friend, but an actual yellow-breasted flycatcher in flight.

If he is not sure that his observation was right, the ornithologist will begin a process of logical reflection, comparing point by point first the family characteristics of the flycatchers and then those of the different species, with what he can recall of what he saw. But what made him aware of the bird at all was not logical thought but the creation, through the unconscious aid of scientific skill, of the configuration of a yellow-breasted fly-catcher out of clues that to the other man were not only meaningless but not even fully observed.

The point I wish to stress here is that, in scientific identification where no invention is involved, what the scientific knowledge first does is to take the same hints which to other men have no meaning and intuitively complete them into a meaningful whole. Even though the process is scientifically exact, the intuitive element is creative.

In invention this creative aspect assumes predominant importance. Unless the inventor is willing to relax the meticulous step-by-step procedure of logical science and let scientific clues suggest generous, or even extravagant, technological conceptions, he will get nowhere. For what the intuitive process of invention does is to lift reason out of the established paths of technology, when they have become ruts, and to put the mind upon a new road leading more directly to its goal.

It is thus when the various habitual images, arising from the clues given by experience, fail to give satisfactory results, that the problem shifts from one of recognition to one of inventiveness. How this occurs is well illustrated by Professor Köhler's studies of problem solving by anthropoid apes.[1] In one of his experiments, he placed an ape in a cage where food was temptingly near but out of its reach. The ape immediately applied its former practice of reaching through the bars. This failed. It tried the habitual method again and again without result. Then it sat down in discouragement. But the food was tempting. Suddenly it picked up a stick which had been in sight all along and which it had never before used as a retrieving implement. Without any awkward trial and error, without any preliminary steps, it reached out with the stick beyond the food and brought it in.

As with recognition, this intuition consisted in instilling meaning into otherwise unrelated clues. But it further involved creating, out of formerly unrelated hints, a conception which not only fitted the situation but which the ape had never conceived of before. It is in this creation of novelty by intuitive contrivance that the essence of invention lies.

Now it is interesting that during all the preliminary struggle the stick had been in plain sight, but had had no significance to the ape which later solved the problem. It was only when a flash of insight combined into a new meaningful whole the hints provided by the presence of the food, the stick, the ape's arm, and by its unsuccessful attempts at reaching, that success came. Even in this very low order of invention, it was necessary to use the wisdom of past experience to escape from the bondage of past experience, and it is that which makes invention so difficult.

If the stick is placed in such a position that it and the food cannot both be seen at one time, many apes cannot solve the problem. With very simple minds, all elements of the solution must be visually present at one time for the clues to be sufficiently strong for the new whole to be conceived. Even with skilled engineers and scientists, the influence of such a favorable setting is great.

PASTEUR DISCOVERS PREVENTIVE INOCULATION

Often the accidental proximity of the component elements of the solution have been the prelude to great invention. Thus just before he discovered preventive inoculation, Pasteur's illness caused him to neglect a culture of chicken-cholera microbes that he was studying. In this study, he had already observed that those few chickens which became infected and yet somehow survived the disease were thereafter immune against further infection. When after illness he returned to work he found that the undernourished microbes had lost most of their vitality. Thus by chance, the knowledge that infection gave immunity against reinfection and that protracted malnutrition produced attentuation of microbial vitality were brought to his mind when it was actively engaged in seeking means of preventing infection.

This enabled him to see a startling possibility. Might it not be possible to find means of so attentuating the microbes which caused disease that a person could be inoculated with them with no risk and only minor discomfort? Then might not the fact that the person had had the disease even in a mild form render him immune to it thereafter? He inoculated his chickens with the enfeebled microbes. The chickens displayed only the mildest symptoms of cholera. But thereafter they were immune to infection by germs of full virulence. Preventive inoculation had been discovered.

Most experimenters would have thrown the neglected microbes out as unsuitable for experimental use. Even if they had bothered to examine them under the microscope the feebleness of the microbes would have made their unfitness for experimental use seem all the more clear. Only to a mind peopled with vivid concepts of disease, and sensitive to implications quite outside its own expectations, would the apparently disconnected elements of this problem come together as a richly meaningful whole.

Unquestionably, this favorable setting occurred by chance but as Pasteur so often said, "Chance favors the mind which is prepared," and well might he have added, "but only if the mind has retained its freedom and resourcefulness in spite of the discipline of preparation." It is the need of this combination of discipline and freedom that makes scientific and engineering invention so difficult.

INVENTION OF THE AUTOMATIC LOOM BY NORTHROP

Let me take a concrete example. About 1860, loom manufacturers began trying to devise an automatic loom. By 1890, all the elements of an automatic loom had been devised except that no way had been found automatically to thread the bobbin yarn through the eye of the shuttle. Without this, an effective automatic loom could not be made.

One day a machinist named Northrop, who had been working on spinning machines, went to his chief and said he thought he could invent an automatic loom. At some time in his work a flight of inventive intuition taking off from his background of knowledge of spinning had given him a vision that the problem of threading the shuttle could be solved if the old conception of threading the yarn through the circular shuttle was aban-

[1] "*The Mentality of Apes*," W. Köhler, Harcourt, Brace, New York, N. Y., 1925, pp. 32–40.

doned and instead the yarn was wound into an open eyelet.

This inventive insight was followed by a long period of experimentation until he devised a shuttle in which a curved entrance into the eyelet was so patterned as to correspond with the whirl of the yarn as it came off the spindle. Then by merely anchoring the yarn and sliding the shuttle across the loom, the yarn as it unwound from the spindle wound itself into the eyelet. Thereafter, the faster the shuttle flew back and forth in the loom, the faster the yarn unwound and the more the twist of unwinding held the yarn in the shuttle eyelet.

With Northrop, as with the ornithologist who recognized the flycatcher, clues were meaningful which to others had been without meaning in spite of years of searching. Everyone who had ever worked on looms knew that the shuttle yarn whirled into a cone as it came off the spindle, but did not think of it in relation to the problem of threading the shuttle eye. But with Northrop, the nature of his past work caused him to approach this problem from an angle other than that from which his predecessors had looked. This enabled him to see the old factors in a new light.

As this case illustrates, the process of logical engineering development often comes to an impasse because the engineer is following principles that worked at the beginning but have come to the end of their utility. He is like a man who has planned to climb a mountain and has followed a trail which leads him near to the top but not necessarily into the best position to attain the top. To go on, he must see the mountain as a whole, recognize that he must go back and start from another point of departure in order to surmount the obstacle. Thus, inventive insight often involves seeing that the problem itself is not what has been assumed, but is of another sort involving another angle of approach.

To do this is difficult especially for the highly trained mind. For just as a man who has made the wrong turn on a detour finds it hard to make himself return to the place of deviation, so it is hard for anybody who has long studied and worked along one line of approach to try another. This is particularly true if the needed idea involves a fundamental change. In that case, to make the other approach involves more than going back and thinking from another angle. It involves reorganizing the complex structure of knowledge which he has developed with such care and pains.

The situation is very like that of the electrical current in downtown New York. In that part of the city, due to the fact that it was one of the places first wired for electric lights, direct current has been provided from the start. Every electrical device is adjusted to it. If Mayor La Guardia were to state the unquestioned fact that for ordinary commercial uses alternating current is better than direct current, and add that "effective next week alternating current will be installed in downtown New York," a storm of protest would break out. Most electrical devices would be useless until adjusted to this fundamental change.

Just as with direct-current installations, the greater and more intricate the structure of thought involved, the greater the difficulty of change. With a man who for a long time has followed one angle of approach, a fundamentally new approach may even involve changing from an expert who is working in an area where he is highly skilled and completely at home into a novice who is feeling his way. Thus the approach to the problem of drying ink through internal chemical reaction instead of mechanical drying meant that all the work on that problem which the mechanical engineer had done and the ability which it had given him were made obsolete. The problem was no longer even in his department. The internal resistance to this is inevitably great. Every habit of thought and every desire involved unite in opposition.

If others are similarly placed, the united opposition may be insurmountable even after the discovery is a well-established fact. Thus, when Pasteur, looking through his microscope at what had been known for decades—the appearance of active microbes in the course of disease—saw this not as the result of disease but as its cause, he rendered obsolete much of existing medical science. Since he had no formal medical education, he had little internal resistance to overcome. But the announcement of his discovery marshaled against him the organized and bitter opposition of the whole medical profession. Their thinking processes and their practices had all been developed on a different stem. To accept the new point of view involved giving up most of their previous ways of thought and practice, admitting that they had been wrong, and then starting the slow painful path of learning new ones.

The influence of established scientific opinion upon the inventor through the power of suggestion is strong even when overt opposition does not deter him. To invent he must so free his mind from the influence and the logic of his own past and that of his fellows, that his unconscious intuition can see clues which he and others have overlooked, and build out of them novel conceptions.

Often in order to get sufficiently away from the effects of stereotypes of thought he must utilize some external means of releasing his mind from too self-conscious and logical control. Thus new insight often comes to an inventor when he is relaxed or diverted; when he is out walking, when he is working on something else, when he is about to go to sleep, or when he wakes up in the night. Only then is his mind sufficiently relaxed to free insight from bondage to the habitual.

FAITH AN ESSENTIAL DRIVING FORCE

When, as is often the case, the initial insight is vague and obscure—just a hint itself that something lies in a new angle of approach—the inventor must have great determination and patience in order to keep on until he has achieved success. What brings this about? Certainly not inborn "sticktoitiveness" alone. When, for instance, Pasteur's insight told him that the germs might play a major part in disease, he kept on largely because of faith—because he was convinced that, if his intuition were true, the power of medical science to cure disease would be tremendously changed and the welfare of mankind immeasurably served.

His determination, however, rested upon more than this—it rested upon his conviction that if *he* persisted, *he* could probably accomplish the result. He knew his experimental method. He was skilled in it and aware of his skill. He saw the relation of his particular abilities to the solution of his problem. It was because he not only had faith in the value of what he might discover, but faith in himself as the person to make the discovery that he kept on. Little inventive persistence occurs unless both aspects of faith are present; and as with Pasteur, faith in one's insight and in oneself is essentially a by-product of technical understanding and high intuitive skill. The pathway to developing the drive that keeps one going until success is the slow hard one of developing the wisdom and skill that make success possible.

Quite apart from the driving force of faith is that of inner tension. To make this clear let me again cite a very humble example. When a person has seen an acquaintance whom he once knew well but cannot place, he feels a sense of strain. He has a clear image of the man he has seen. He knows that he has somewhere in his mind a clear configuration of who he is. Both are there. But he cannot bring them together into a common conception. This makes him restless. He keeps turning the problem over in his mind even when he is trying to think of something else. The more nearly he seems to "get it," the more strain he feels. Then in some moment of relaxation just who the person is comes to him in a flash and he has a great sense of relief.

So with incipient invention. If the knowledge of the inventor and the clues which will bring the invention into being have been brought nearly into position to provide the inventive

insight, the inner tension will be strong. The man will keep turning the problem over in his mind. He will not be able to get away from it by day or night. As he nears his goal he will become increasingly excited. He will be impatient of the interruption of his work even for sleep or food. It is no wonder that the sudden release of such inner tension is often described by inventors as a "flash."

INTUITION VERSUS LOGIC

Curiously, in spite of the invaluable part that intuition plays in human affairs, it is common for people, especially if technically trained, to consider it as of a lower order than logical thought and to pride themselves on being exclusively logical thinkers. Logic is so much more tangible and systematic, and so easy to put into words, and hence to teach, that mute unconscious intuition is decried as unintellectual and emotional.

What are the facts? Shakespeare, Bach, Pasteur, Edison, in their moments of greatest originality were not logical but intuitive. Thegenius of a great musician in sensing the structure of a composition, the insight of a great doctor in diagnosing an obscure disease, and the insight of a great inventor are intellectual attainments of as high order as any logical deduction.

True, insight can also be of a very low grade. Even apes can exercise it. But as Vannevar Bush, in developing his integrating machine, has shown, complicated logical processes can be performed even by a machine.

Nor is intuition more emotional. Unquestionably, as when a thirsty man in a desert suddenly sees a mirage, emotion and desire can corrupt intuition. But emotions also lead reason astray. Indeed the process of logical reason is so effectively subject to emotional manipulation that self-deception is known the world over as "rationalization."

But isn't scientific logic quantitatively exact while intuition is quantitatively indeterminate? It is. But if one examines the application of quantitative science to reality, one finds that the exactness of scientific logic is limited. Logical quantitative methods are accurate only in regard to abstractions or when applied to "abstract materials;" to unnatural creations of man such as iron and steel; beams and railroad rails; things from which all the variables of nature have been carefully excluded.

When one deals with normal natural phenomena the realistic precision of intuition is often greater than any which abstract quantitative methods can provide. This is of course true in identifying the workmanship of an old master or recognizing a long-lost friend. But even with so simple a phenomenon as a batted ball, no scientist or mathematician can predict its flight as it leaves the bat with either the speed or the precision of a major league fielder who sees the ball hit, turns back, and runs almost to the exact place where it alights, integrating by intuition the whole complex of unmeasurable variables. In much of modern life, the most effective understanding is when scientific quantitative accuracy and scientific intuition both play a part.

It is important to bear in mind the high intellectual quality, the unemotional soundness, and the realistic integrity and precision of refined insight. For insight is the father of invention far more indisputably than necessity is its mother.

PSYCHOLOGICAL REQUIREMENTS OF INVENTIVENESS

What then, to recapitulate, are the psychological requirements of inventiveness and the factors which favor them?

First, it is essential that the inventor "know his stuff." If his inventions are to be of use in modern industry he must be well equipped with scientific understanding. This doesn't mean that he should have endless rules and formulas at the tip of his tongue. Such inert knowledge will be a burden to him. What he needs to have is a vital knowledge of basic scientific principles and have developed realistic creative skill in using them, by practice and experience.

As a second qualification the inventor must have, and must continuously develop against the encroachment of custom and habit, the capacity to construct bold effective and varied configurations and concepts out of the clues which lie concealed in technological problems. The more he knows, the more difficult it will be for him to do this. What I fear most as an obstacle to inventiveness in industry is that as a young engineer pursues the long slow path of education and experience, he succumb to the past as New York has to its direct-current installations.

The most important way out of this dilemma is to make education and experience more fundamental. If in school and at work the resourceful young engineer is required to shun memorized formulas and to go back to basic principles for the solution of his problems, the process of developing technical competence will in itself give him the basic understanding and way of thought essential for inventiveness. When logic thus goes back to fundamental origins, and is in that sense original, logical development and inventive insight come close together. Both make possible fundamental shifts to more profound bases of approach. Even so, with truly baffling problems, logical exploration can only do the groundwork for the flight of intuitive insight. If such insight is to occur, the process of education in school and industry must make provision for its exercise. Again and again the formal paths of logic must be abandoned and the relaxaticn provided which permits insight unconsciously to find its way.

CHANGE OF MENTAL SCENE

Another aid to the freeing of inventiveness from the confining influence of learning is to assign to resourceful young men creative problems outside of their customary field of work. Such an alien approach, as it so often has with great inventions, may provide a suggestive setting which will lead to a solution of the particular problem. But more important is the fact that it will tend to free able minds from the confining adhesions of their customary thought.

Since inventiveness is not confined to major discoveries such change may be more frequently provided in less formal ways. Any engineer or executive who is worth his salt should show inventive talent in his daily work and be required to do so. Even in reading, rumination, and talk, the power of creative intuitive thought should be exercised and developed. Much can be done to stimulate this by bringing young engineers into frequent serious-minded association with able men of other backgrounds. By so doing they will be caused to see their own problems from new slants and in the light of different practices and principles.

Far more than senior executives usually realize, what they do, what they are, and what they admire in their subordinates determines what those young men who work for them do, think, and become. Through example, they can keep their juniors in the habit of resourceful yet sound intuitive judgment. They can inspire in them admiration for and determination to imitate the people who have the daring and ability to abandon traditional ways of thought, and who while doing so arrive at conclusions which logic may at first refute but later accept. A third psychological factor favoring inventiveness is thus widespread admiration for sound intuitive thought.

A fourth is determination. But if a young man has vital and profound scientific understanding, if he is resourceful in its intuitive use, and if he admires and cultivates these qualities, I have little fear that he will lack the faith which gives determination. Few men who have attained high scientific intuitive skill through the hard path of study and experience lack the determination to use their skill well. By example and by the work they assign and by the qualities to which they give recognition, executives can do much to cause their outstanding subordinates to revere and study fundamental science and also to cherish and develop the intuitive spark within them which enables them to put this science into richly creative use. Young men of promise can do even more to accomplish this for themselves.

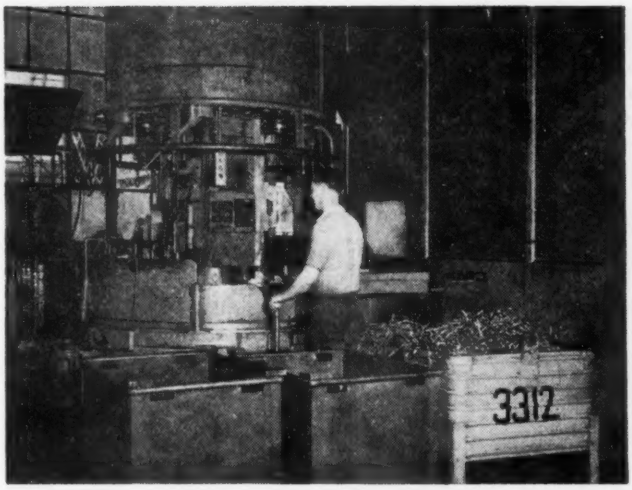

FIG. 1 TOTE BOX FOR COLLECTING SCRAP FROM AN AUTOMATIC PRODUCING A BIG VOLUME OF CHIPS

FIG. 2 FORK TRUCK, HANDLING TWO TOTE BOXES, HEADED FOR THE CHIP-DISPOSAL PLANT

CHIP-DISPOSAL METHODS

By FRANK J. OLIVER

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DISPOSAL of chips is no new problem. Borings, turnings, and shoveling turnings or crushed chips have been standard blast-furnace grades of scrap for years. Both cast-iron borings and steel turnings have been briquetted since the late 20's. The tremendous increase in production of war goods in the last few years, however, and the erection of enormous machine shops with thousands of machine tools generating scrap has made chip disposal a big-scale material-handling problem. Then, too, scarcity of good foundry scrap has forced many a big integrated shop into briquetting its borings and turnings for the cupola, and scarcity of heavy melting steel scrap, plus W.P.B. directives, has forced steel mills to charge crushed turnings or briquettes into the open hearth or electric furnace. Within the past few years, a number of mills have installed briquetting presses for this purpose.

Segregation of alloy chips which for the past two years had been urged upon industry and encouraged] by juicy premiums for alloy content, was made mandatory on July 6, 1943, by W.P.B. Order M-24-C. This order was issued not only because of the then scarcity of ferroalloys but also because ordinary carbon-steel melters were having difficulty in obtaining alloy-free scrap. To release some of this carbon scrap, the alloy producers were then directed to use a certain percentage of alloy scrap in each heat, much as they would prefer to melt down a charge of carbon-steel scrap and supply the right amount of alloy by ferroalloy additions. Juggling with scrap additions is expensive and time-consuming.

Aided by cutbacks in alloy-steel requirements, the alloy situation has improved so rapidly that all allocation rulings were expected to be lifted off the ferroalloys early in 1944, but the ruling as to the use of alloy scrap by the mills will still be in force. Already this situation has affected the price of shoveling and briquetted turnings to the extent that premiums for alloy content are no longer being paid in the East. At one time, premiums for high nickel content (up to 5.25 per cent) ran as high as $14 a ton on the open market. It is the author's belief, however, that where alloy chips are carefully segregated, crushed, or briquetted, and then shipped in carload lots, all of one analysis, premiums will still be obtainable. What the mills object to is roughly segregated scrap, with a few lead bearings and lunch garbage thrown in. The illustrations herewith exemplify the kind of chip-classification and disposal methods that pay dividends in this respect.

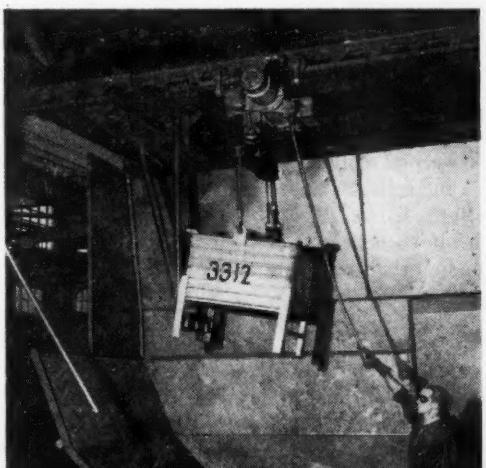


FIG. 3 TRIP BAR IN COMBINATION WITH OVERHEAD TRAIN-RAIL HOIST FURNISHES MECHANISM FOR DUMPING TOTE BOXES AT BULLARD PLANT

SEGREGATING SCRAP AND ORDERLY SALVAGE METHODS

As long as alloy turnings must be used by steel mills, scrap buyers are urging industrial producers to cooperate in segregating turnings and in introducing more orderly salvage methods. Out on the west coast, for example, where mushrooming industries have still to learn good salvage methods, the Columbia Steel Company is taking full-page advertisements urging proper segregation of scrap. The W.P.B.,

Contributed by Special Research Committee on Cutting of Metals and presented at the Annual Meeting, New York, N.Y., Nov. 29–Dec. 3, 1943, of The American Society of Mechanical Engineers. Condensed.

through its industrial salvage branch, has recently issued a 244-page "Salvage Manual for Industry," which goes into the matter of segregation in great detail.

In the case of nonferrous scrap, segregation is still very much worth while from a monetary point of view. There are at least eight different recognized scrap grades of copper, ranging from pure copper to an alloy running 30 per cent copper content, and the difference in price obtainable can be as great as $95 per net ton. The O.P.A. ceiling on copper turnings, for instance, is 9.75 cents per lb; refinery brass is worth only 5 cents, while bell metal tops the list at 15 cents per lb, or $210 a net ton.

Aluminum alloys are perhaps the most difficult to segregate because the chips look so much alike. Therefore it is essential that these materials be segregated at the source in some of the ways to be illustrated. Aluminum-alloy borings and turnings bring 6 to $7^1/_2$ cents per lb under O.P.A. ceilings.

Segregating the various classes of chips and getting them from machine tool to freight car is primarily a problem in material handling. The types of container used to segregate scrap at the source depend upon the basic production practice of the plant and the amount of processing subsequently given the scrap. On big chip producers like the Bullard Mult-Au-Matic shown in Fig. 1, where stringy alloy-steel chips are being handled, a big tote box like the one at the right is useful, although as will be shown in another illustration, smaller boxes serve the same type of equipment. Much depends upon the frequency and the method of collection. Incidentally, the number on the box (3312) is the S.A.E. specification number of the steel.

Numbers or color systems or both in combination are used in marking tote boxes of segregated materials. Table 1 gives the

TABLE 1 BULLARD MARKING SYSTEM

Material	Tag color	Container color scheme
Cast iron	No tag	Gray
S.A.E. 1020	No tag	Gray
S.A.E. 1045	No tag	Gray
S.A.E. 1112	No tag	Gray
(Note: Cast iron and steel are not mixed in one container)		
S.A.E. 3250	Orange	Orange 3250
S.A.E. 3312	Orange and green	Orange and green 3312
S.A.E. 4640	Orange	Orange 3250
S.A.E. 52100	Orange and green	Orange and green 3312
N.E. 8817	Orange and blue	Orange and blue
N.E. 8949	Orange and blue	Orange and blue
H.S. Steel	Orange and red	Orange and red
Bar No. 15 bronze	White and red	White and red
Phosphor bronze	White and blue	White and blue
Ampco No. 18	White and yellow	White and yellow

marking system in use at the Bullard Company plant in Bridgeport.[1] The tag designation listed in the second column is placed in a holder on the side of the machine and tells the driver of the fork lift truck what tote box to spot at the particular machine. By providing leg receptacles at the four corners of each tote box, it is possible to stack one upon the other and thus enable one fork truck to transport two tote boxes to the chip-disposal plant, Fig. 2. In the unbaled state, the chips are quite light, weighing only about 20 to 30 lb per cu ft.

A MATERIAL-HANDLING PROBLEM

Dumping the tote boxes is another phase of the chip-handling problem. Fig. 3 shows how a trip bar (left) is used in combination with an overhead train-rail hoist at the Bullard plant. The turnings are being dumped on a chip deck from which they are pushed into the feed hopper, a hammer-type chip crusher.

Fig. 4 shows another method of handling curly turnings out of a Bullard Mult-Au-Matic. This scene is from the Cincinnati plant of the Wright Aeronautical Corporation. There are only two main types of steel handled here, a $3^1/_2$ per cent nickel alloy for connecting rods, crankshafts, and gear blanks, such as are being turned here, and Nitralloy steel for cylinder barrels, which are turned on Fay automatics. Hence segregation is simple. The container shown holds about four bushels of loose turnings.

High-lift electric fork trucks pick up the tote boxes, shown in Fig. 4, and dump the contents into a narrow side-dump trailer car which has a capacity of about 35 cu ft. These cars were made by a mine-car manufacturer and are regularly used in that service.

When a train of from six to ten 10 cars is made up, a gasoline-driven tractor unit hauls them to the chip-reclamation plant. At the Cincinnati plant of the Wright Aeronautical Corporation this is a separate building.

In Fig. 5, one of the side-dump trailer cars has just been dumped on the charging deck in front of the chip-crusher hopper. The hopper hatch can be seen at the left. These curly chips are typical of the product of finning operations on Nitralloy cylinder barrels turned on Fay Automatics, at the Wright Aeronautical Corporation, Cincinnati plant.

Another method for collecting chips, for example, off a wood-block floor, which is a difficult task for a broom, involves the use of an industrial vacuum cleaner. Aside from keeping the chips from sticking to rubber heels, under today's conditions of material shortages, this type of housecleaning is much more effective than broom and dust bin and assures 100 per cent chip recovery.

Fig. 6 would remind one of the fittings used in domestic vacuum cleaners. There are literally hundreds of such fittings for industrial use. This method of cleaning chips from a big machine-tool casting not only recovers the chips but also cleans the casting prior to assembly. A casting of this size would be difficult to roll over in order to dump the chips, even with the aid of a crane. Portable vacuum cleaners of the type shown are made in capacities from $^3/_4$ to $7^1/_2$ hp. Stationary central units for serving an entire plant are made in capacities up to 100 hp.

A delicate milling job was improved by removing chips at the tool point. In the right foreground of Fig. 7 is the industrial-vacuum-cleaner unit with an additional cyclone-type separator to collect metal chips. Mounting the unit on skids makes it possible to use one vacuum cleaner for various dry-machining setups on other machines. In an automotive plant, another vacuum unit not only salvages pure babbitt from the finish-boring operation on the main bearings at the rate of 1000 lb a day, but also serves to clean the engine block in preparation for the next operation on the assembly line. Some manufacturers of metalworking tools are now designing vacuum equipment right into their machines as part of the original equipment.

CRUSHING THE TURNINGS

A ring-type crusher is often used to reduce long curly turnings of carbon or alloy steel, such as were shown in Figs. 4 and 5. It is also applicable for crushing brass turnings. The ring crusher reduces the bulky turnings into a product known in the scrap trade as short shovel turnings. As such they occupy one third as much space in gondola cars as loose turnings of the same weight and therefore assure loading a car to full weight capacity—a "must" under wartime transportation conditions. Crushed chips bring a premium price and hence the machine will soon pay for itself. Besides, crushers make centrifuging much easier for oil extraction and subsequent recovery.

Centrifuging is the next step after the crushing operation. Fig. 8 shows a scene in the chip house at the Cincinnati plant of the Wright Aeronautical Corporation. Here hammer-type crushers are used and the broken turnings are elevated into a hopper by means of a slot- or pan-type conveyer just discernible

[1] A description of chip reclamation at the Bullard Company appeared in MECHANICAL ENGINEERING, June, 1942, pp. 457-458.—EDITOR.

FIG. 4 HANDLING CURLY TURNINGS AT WRIGHT AERONAUTICAL PLANT

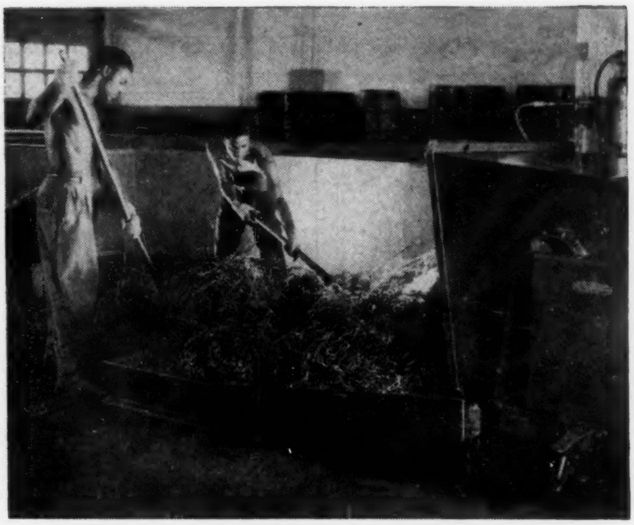


FIG. 5 DUMPING A TRAILER CAR OF CURLY CHIPS AT THE CHIP-CRUSHER HOPPER

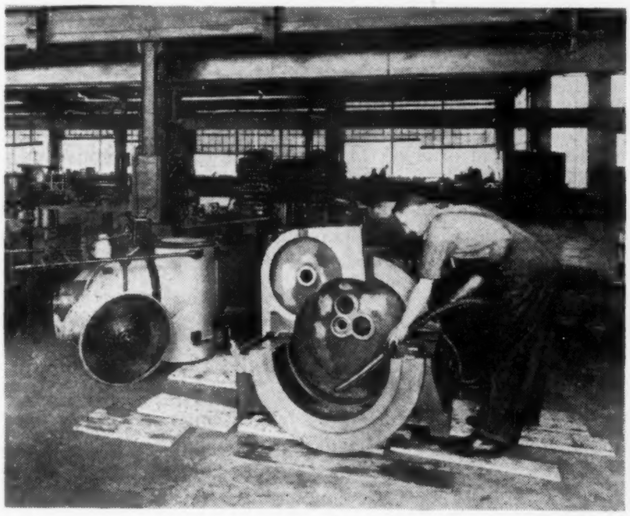


FIG. 6 INDUSTRIAL VACUUM CLEANER IS USED TO ADVANTAGE IN SALVAGING CHIPS FROM LARGE CASTINGS, INCIDENTALLY CLEANING THE CASTING AS WELL

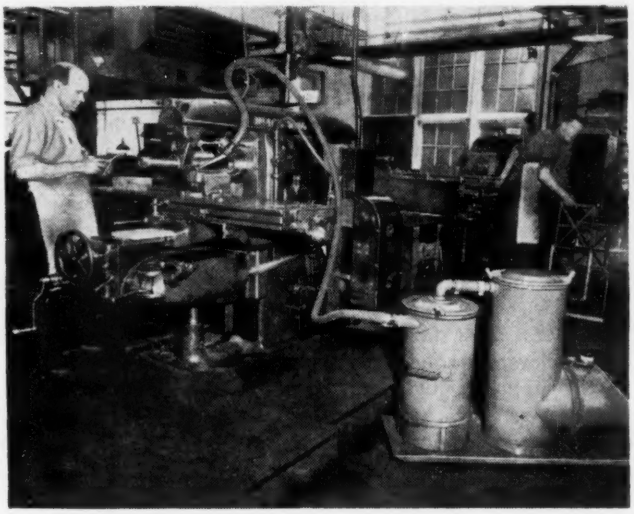


FIG. 7 A DELICATE MILLING JOB WAS IMPROVED BY REMOVING CHIPS AT THE TOOL POINT BY USE OF AN INDUSTRIAL-VACUUM-CLEANER UNIT

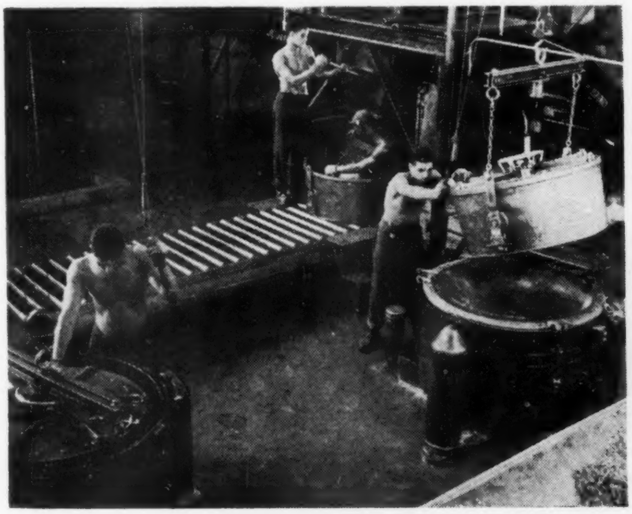


FIG. 8 VIEW IN THE CHIP HOUSE, CENTRIFUGING THE CUTTING OIL FROM CHIPS

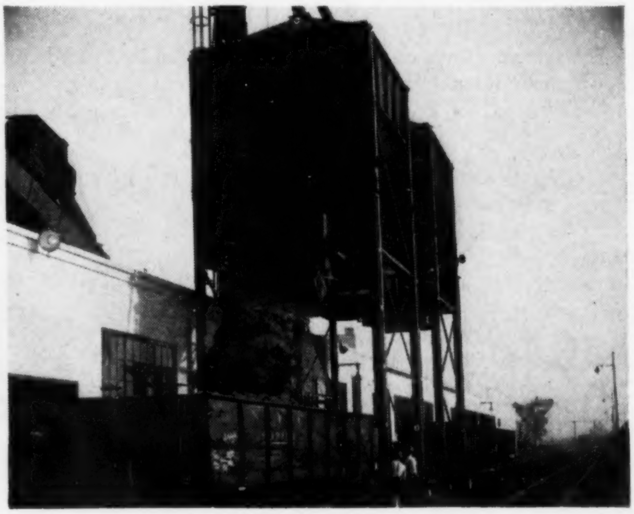
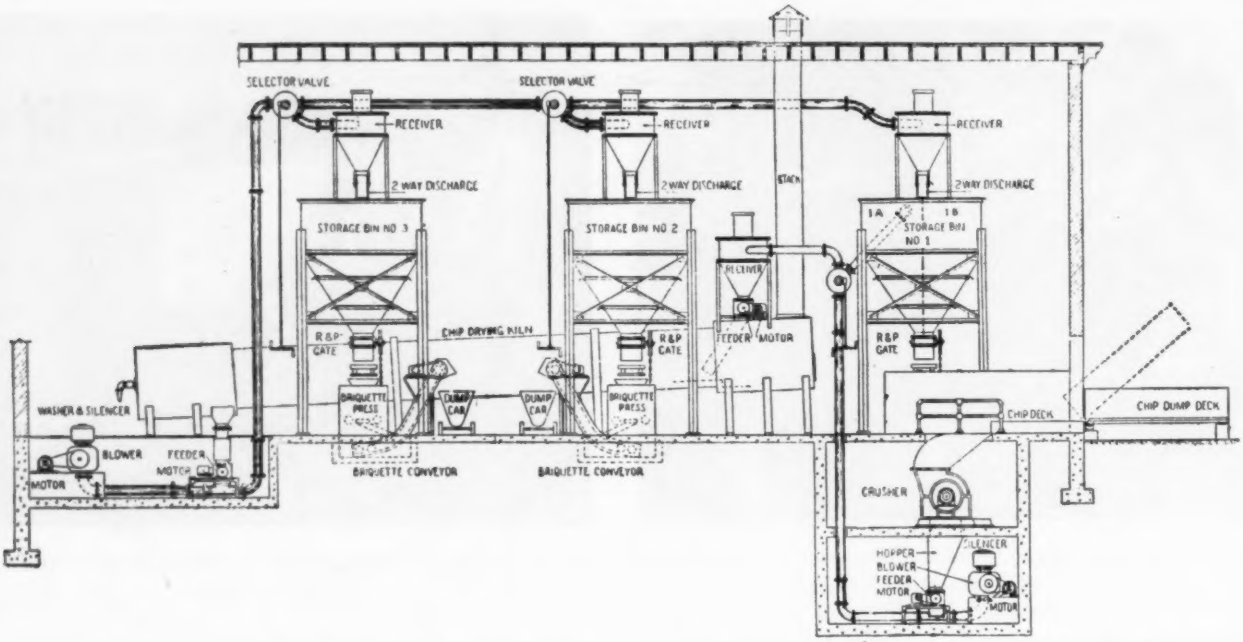


FIG. 9 TWO 100-TON HOPPERS AT THE WRIGHT CINCINNATI PLANT USED FOR STORING CHIPS AND CHARGING GONDOLAS



Courtesy National Conveyors Company

FIG. 10 LAYOUT OF CHIP-RECLAMATION PLANT UTILIZING PNEUMATIC TUBE FOR CONVEYANCE

at the right rear. One of the baskets is shown being charged from this hopper. The chip wringers extract as much as 98.6 per cent of heavy cutting oil from chips. This oil is treated in a unit which combines accelerated settling of fine solids by heating the oil to reduce the viscosity and drive off moisture. Filtering through moleskin, a tightly woven cotton cloth, finally makes the oil fit for re-use.

Fig. 9 shows the final disposition of chips at the Wright Cincinnati plant. The two 100-ton hoppers were built before W.P.B. restricted the use of structural steel for this purpose. A bucket elevator brings the dry chips from the chip house, left, to the hoppers. One holds nickel-alloy steel, the other, Nitralloy-steel chips. A gondola car can be loaded with 25 tons of steel turnings in about 15 minutes. Discharge is by gravity.

The pneumatic type of conveyer, originally designed for handling ash in the powerhouse, is equally adaptable for handling crushed chips. It is flexible in application, space requirements are small, and changes in direction are easily made. Segregation is accomplished by means of selector valves which direct the flow of materials of various alloy content to the proper compartments of storage bins or directly to freight cars.

The system shown in Fig. 10, an installation in an Ordnance Department arsenal, is unusual in that provision is made for drying cutting oil on chips after they have been crushed, lower right. The chips are conveyed pneumatically to a receiver over the feeding end of the kiln. The dried chips are conveyed in the same manner to any one of three 40-ton-capacity storage bins, from which they are fed by gravity to briquetting presses, of which there are two. This plant has a capacity of eight tons per hour. Cast iron as well as fine grades of steel are processed.

MAKING BRIQUETTES FROM SCRAP

Briquettes are more widely used today than ever before, particularly in foundry practice. The Dodge foundry in Detroit was perhaps the first to install a briquetting press, for recovery of cylinder-block and similar cast-iron borings. That was back in 1926 or thereabouts. Other automotive foundries soon followed suit and today the largest installation of briquetting presses is at the Ford Motor Company. In recent years several of the big machine-tool companies who operate their own foundries have installed presses for the same purpose. Several steel mills have also installed presses since the issuance of a W.P.B. order directing the use of chips in steel melting. Previously, loose borings and turnings were a blast-furnace grade of scrap.

Fig. 11 shows cast-iron borings before and after being briquetted. It is interesting to note that at least two gray-iron

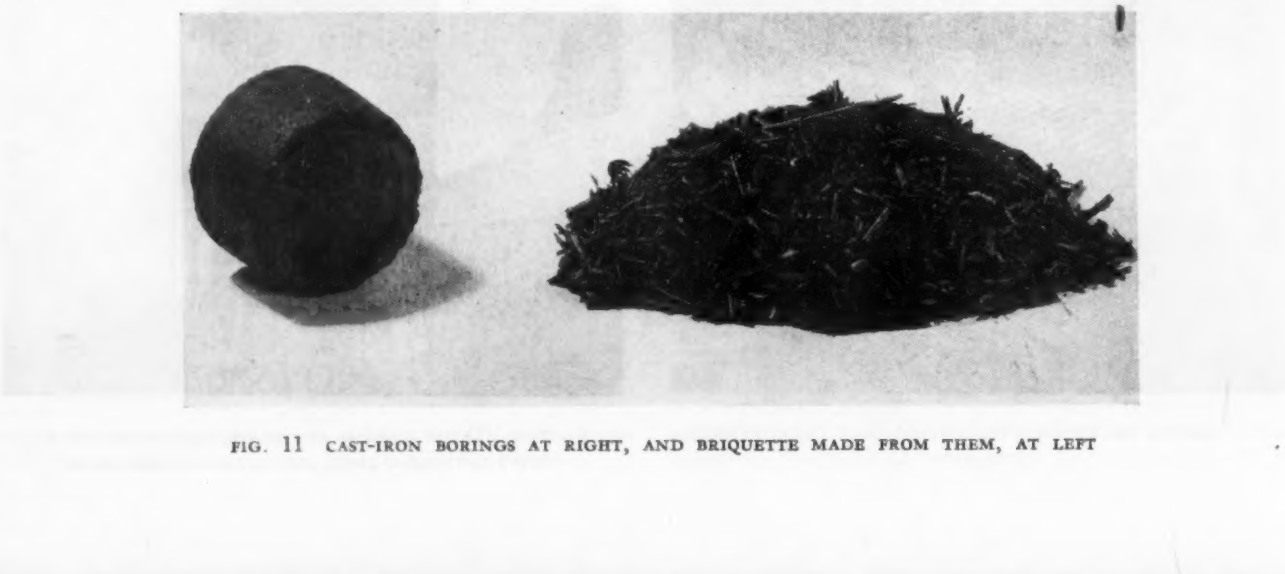


FIG. 11 CAST-IRON BORINGS AT RIGHT, AND BRIQUETTE MADE FROM THEM, AT LEFT

foundries mix a small percentage of soda ash, about 4 lb to the ton, to keep down sulphur build-up in the cupola. Sulphur contamination from cutting oils is a serious problem with steel mills and when scrap becomes freer, it will be a cause of rejection at the mills.

In the case of steel, stringy turnings are crushed before being squeezed into small compact briquettes. The density varies between 65 and 75 per cent. Steel briquettes can be charged in either the cupola, in the open-hearth, or in the electric furnace.

Fig. 12 gives the setup in the new foundry of the Cincinnati Milling Machine Company. The two big hoppers, with slat conveyer discharge to the hopper of the hydraulic briquetting press, were formerly used to hold and feed molding sand into big flasks in the old foundry. The briquettes are conveyed by a short slat conveyer from the base of the press to a conical-bottom drop-cupola charging bucket. At this plant, up to 30 per cent briquettes are used in the cupola charge.

A view of the briquetting press at the Warner & Swasey plant in Cleveland is shown in Fig. 13. Magnetic vibrating feeder is at right. About 42,000 lb of cast-iron borings can be briquetted in 24 hr and 20,000 lb of steel turnings a day in a similar machine. Both presses are direct hydraulic-plunger types. Only a portion of the steel turnings undergo this process at Warner & Swasey. The rest are sold in loose form.

Fig. 14 shows another type of hydraulic briquetting press. Crushed chips are fed to the mold hopper by a vibrating pan, not shown. Precompression takes place by two auxiliary cylinders whose movements serve to close the mold cavity so that the charge is pushed forward and compressed in the main mold as the main plunger moves forward to complete the compression cycle. The main plunger (left) and the compactors then return to their initial position and in

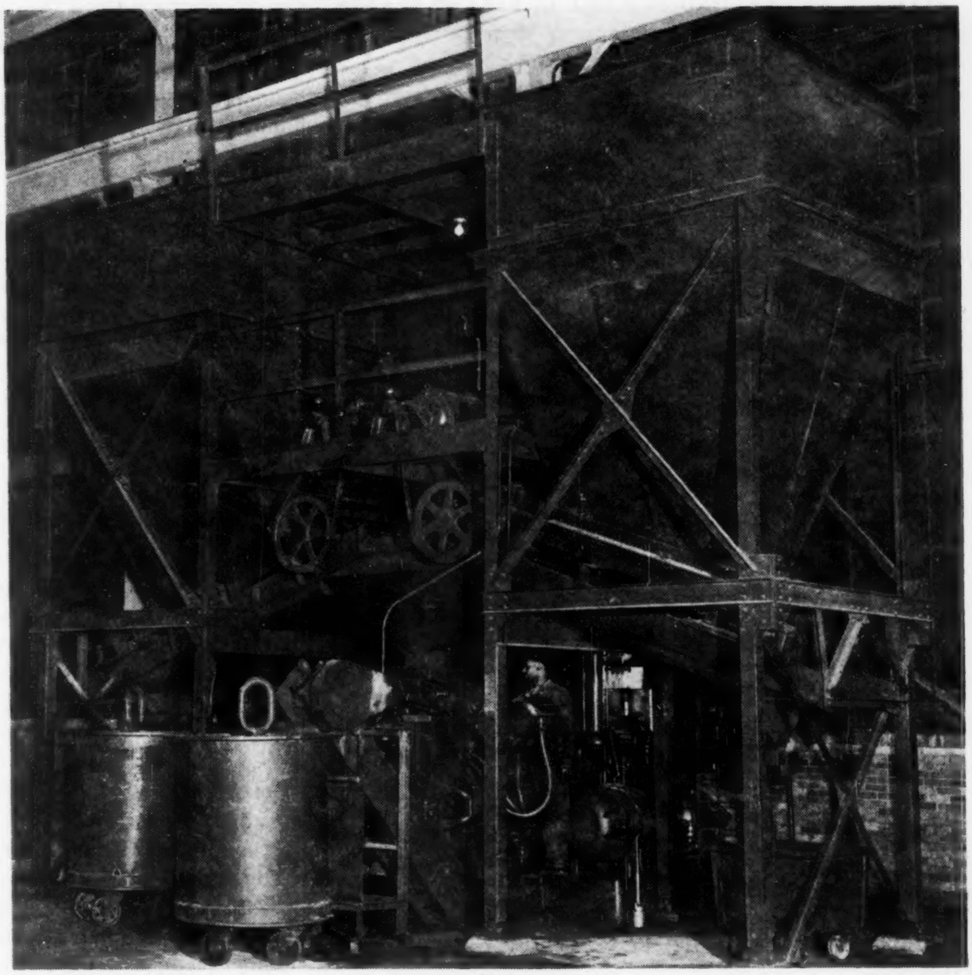


FIG. 12 BRIQUETTING INSTALLATION IN CINCINNATI MILLING MACHINE COMPANY FOUNDRY

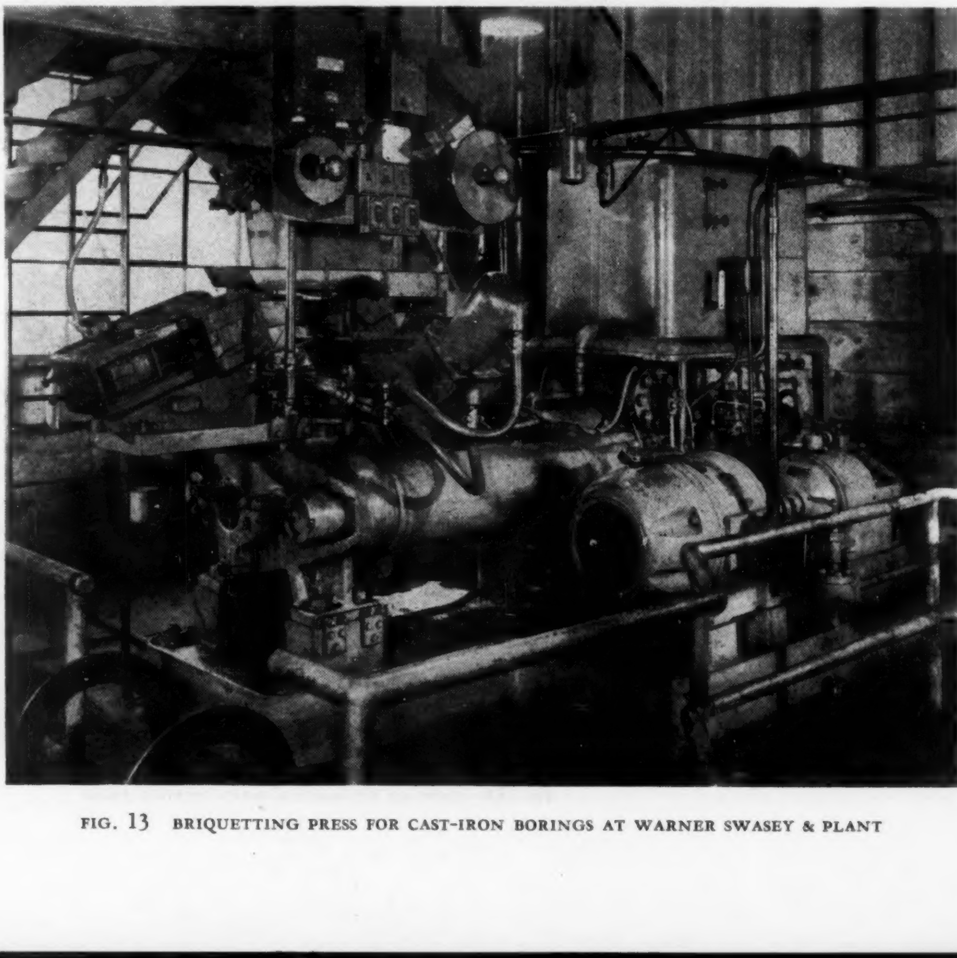


FIG. 13 BRIQUETTING PRESS FOR CAST-IRON BORINGS AT WARNER SWASEY & PLANT

TABLE 2 BRIQUETTING PRACTICE IN VARIOUS PLANTS

Plant	Output, Tons Per 8 Hr. Per Machine		Briquette Size*		Weight, Lb.		Density, per cent	
	Cast Iron	Steel	Cast Iron	Steel	Cast Iron	Steel	Cast Iron	Steel
A	10 to 12**		$4\frac{1}{4}$x$3\frac{1}{2}$	$4\frac{1}{4}$x$2\frac{1}{2}$	9.8	6.8		
B	16**		$4\frac{1}{4}$x$2\frac{1}{2}$	$4\frac{1}{4}$x$3\frac{1}{2}$	6	6	80	65
C	8	4	3 (dia.)	3 (dia.)	$2\frac{1}{4}$	$1\frac{7}{8}$		...
D	20		$4\frac{1}{2}$x3	...	9 lb. 1 oz.	.		...
E	22		$4\frac{3}{8}$x4		11		78	...
F	20 to 25	10 to 14			8 to 9	4 to 5		.
G	35**		4x$3\frac{1}{2}$	7x$3\frac{1}{2}$	8.5	22		
H	30	20	5 (dia.)	5 (dia.)	14 to 15	9 to 10		
I	20	...	4 (dia.)	...	10	.	80	
J	18	15	3x3	4x$1\frac{1}{2}$	4	3	85	75
K	7	.	$2\frac{3}{4}$x$2\frac{1}{2}$	.	3	.	80 to 90	..
L	20		$4\frac{1}{4}$ (dia.)	.	10.5	.	78	

* First dimension is diameter
** Cast iron and steel

the process strip the briquette from the mold. This 325-ton machine makes eight strokes per min, forming briquettes 6 in. diam and approximately $3\frac{1}{2}$ in. high; output is three tons per hour.

Table 2 summarizes briquetting data obtained by an informal survey made by the author's company about a year ago. The first figure in the briquette size is the diameter; the second, the approximate compressed height.

Cost data are of vital concern but are difficult to put on a comparative basis since the method of computing costs varies from plant to plant. A few examples will suffice. One plant estimates power and labor costs at only 60 cents a ton for steel briquettes. Another plant gives a figure of \$6.25 a ton for steel, and \$3.20 for cast iron, including depreciation, power, maintenance, and labor. A third plant says \$2.50 a ton, and a fourth, \$1.75 on cast-iron borings, including "everything." A fifth plant estimates 1.3 man-hours and \$3.95 overhead for steel briquettes. This company, incidentally, increased its output 30 per cent by adding another hydraulic pump. The highest figures given were from \$7 to \$9 a ton for cast-iron borings, and from \$9 to \$11 for briquetting steel turnings.

EUROPEAN METHODS OF SALVAGING SCRAP

A German contraption called a "swarf compacting furnace" has been described in ***Stahl und Eisen***. The swarf or chips are dumped into the furnace by crane and the charge is ignited initially by a small fire of wood or coke. Once started, combustion is maintained by the burning of the turnings themselves, whether they be dry or bright, rusty or oily. Only sufficient heat is generated to cause a small portion of the chips to melt. The greater part is simply broken up by the heat into small lengths and leaves the bottom of the furnace in a compacted form easy to handle. About 10 per cent of iron oxide is formed. The lower portion of the furnace is sprayed with water or internally cooled to prevent caking of the charge. The idea appears to be of doubtful value, when it is compared with crushing.

Another European idea which holds much greater promise is that of "mechanical ingoting" of magnesium and aluminum borings and turnings. A pilot plant was being completed by the Société l'Aluminum Francais just about the time the Germans took over in 1940. The wet and oily chips are first crushed before being transferred to a series of three small rotary driers, with a magnetic separator between the first two. Here the oil and moisture are driven off. Compression takes place in two steps in a hot die. In the first stage, the chips are compressed to about 50 or 60 per cent density. The filled die is then put in a rotary furnace and brought up to a temperature between 500 and 850 F, depending upon the alloy being processed. Next the heated die is returned to the press, where the metal receives its final compression into a solid ingot of practically 100 per cent density. Ingots made in this manner can be used for remelting or for direct extrusion or forging. Although the boundary layers of the chips can be discerned in the ingot, they are completely obliterated in the extruded shape, even when a section is magnified 100 diam. The process is now being developed in the United States.

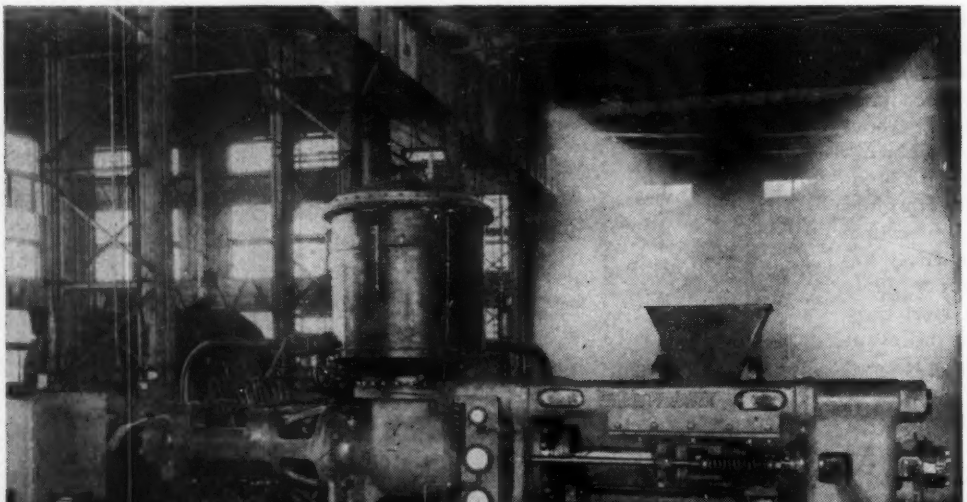


FIG. 14 TYPE OF HYDRAULIC BRIQUETTING PRESS

DIESEL-ELECTRIC LOCOMOTIVE RATINGS

By B. S. Cain

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The Diesel-electric locomotive can be rated in various ways, because each piece of power equipment has its own rating individually, or may be rated collectively with the other equipment on the locomotive.

The locomotive rating may be expressed in pounds force exerted, or in horsepower; in some cases kilowatts produced as well as in Btu consumed. The Diesel-locomotive ratings may be divided into the following classifications:

1 *Drawbar Pull.* This may be obtained from actual tests or calculations. The drawbar pull together with the locomotive speed, represents the work the locomotive actually does and its drawbar-pull ratings on level tangent track, at the various locomotive speeds, should be considered the basic locomotive rating. Drawbar pull and speed form the only rating which should be used for comparative purposes with other locomotives.

2 *Tractive Effort.* This consists of the drawbar-pull rating plus the locomotive journal and air friction, giving us the tractive effort at the wheels, exerted by the traction motors. The traction motors are tested and rated separately under standard conditions but their rating as a part of the locomotive must be considered in connection with the rest of the equipment with which they work. It should be noted that this rating should not be used for comparison with steam locomotives, as their tractive-effort ratings are taken at the cylinders and not at the rails, except when starting. Starting-tractive-effort rating may be taken at 25 per cent of the weight on drivers for either steam or Diesel.

3 *Power From Main Generator or Generators.* The generators are used purely for converting the mechanical power of the engine into electric power to be used by the motors which in turn convert it back into mechanical power at the wheels. Therefore the traction motors have two ratings, one mechanical at the wheels and the other electrical, expressed only in volts and amperes. The generator output has only one rating and that is electrical, expressed only in volts and amperes and not in horsepower, which will be explained in more detail later.

4 *Diesel-Engine Power.* This is divided as follows:

(*a*) The horsepower to the main generator, which horsepower is used for traction purposes only. It should be noted that this horsepower rating is sometimes used as though it applied to the entire locomotive, although it is really only a convenient figure in co-ordinating the engine with the transmission. This rating, like all engine ratings, may vary considerably with change in outside air temperature, grade of fuel oil, altitude, etc.

(*b*) The gross horsepower of the engine consists of the horsepower to the main generator, plus the power to all the auxiliaries. The auxiliary load is usually between 4 and 10 per cent of the total, depending upon the design and upon the class of service in which the locomotive operates. This is another rating that is sometimes used for the entire locomotive because it is the highest figure which could be used (even though it is not necessarily the maximum that the engine can produce).

(*c*) Indicated engine power is obtained by the use of indicator cards or may be estimated by obtaining the engine friction at various speeds and adding this to the gross horsepower. The indicated horsepower is that actually exerted at the engine cylinders, which is known as the cylinder horsepower.

5 *Thermal Rating.* This is the locomotive rating as expressed in Btu per hour, or gallons of fuel oil per hour, the fuel oil used having a known Btu value. This includes all fuel burned in one or more engines and in heating boilers if used.

DRAWBAR-PULL RATINGS

The drawbar-pull ratings of a Diesel locomotive may be obtained by the use of a dynamometer car. If a true comparison is to be made between a steam and Diesel locomotive, it can best be made by the use of a dynamometer car, using the same car and crew to perform both tests. The actual drawbar pull obtained may be different from the calculated drawbar pull at various speeds, due to the fact that the calculated results are based upon the engine producing a given horsepower while, actually, the Diesel-engine horsepower varies, sometimes only slightly and sometimes to a greater extent, due to the many operating conditions encountered. Dynamometer-car tests will not be discussed further except to emphasize that the locomotive should be tested so that its full capacity ratings at the drawbar will be obtained at all locomotive speeds.

TRACTIVE-EFFORT RATINGS

The tractive-effort ratings can be obtained from the drawbar-pull data by calculation, using the Davis friction curves. The tractive-effort rating in starting, depends upon the weight on drivers, regardless of available horsepower. This was frequently taken as 30 per cent for Diesels and 20 to 25 per cent for steam. In recent years 25 per cent has been generally adopted for both steam and Diesel. The tractive effort may be calculated directly and with greater accuracy from the generator and motor characteristics obtained from shop test.

Fig. 1 shows a typical locomotive characteristic curve. The portions *AB* and *CD* represent substantially full utilization of engine horsepower. The parts *BC* and *DE* show some reduction in horsepower because the generator voltage has reached its limit (section *AB* on Fig. 2). At *C* there is a change in the connections of the motors, from *A* to *C* motors in series, and from *C* to *E* they are in parallel.

The characteristics of the direct-current series-wound traction motor are such that at low speeds, high tractive effort corresponding to high current is obtainable with relatively low voltage at the motor terminals. High speeds with decreased tractive effort require increased voltages and lower currents. The increase of voltage with decrease of current is also necessary to utilize the full power of the Diesel engine.

The power which the locomotive can deliver is limited in two different and distinct ways: (1) The Diesel-engine output is limited, regardless of the speed and tractive effort of the locomotive. (2) The length of time during which the electric transmission can deliver power is limited, over part of the range, by heating of the equipment. The most important factor in electric-transmission heating is generally the current in the motor and generator windings. Voltage and speed also have

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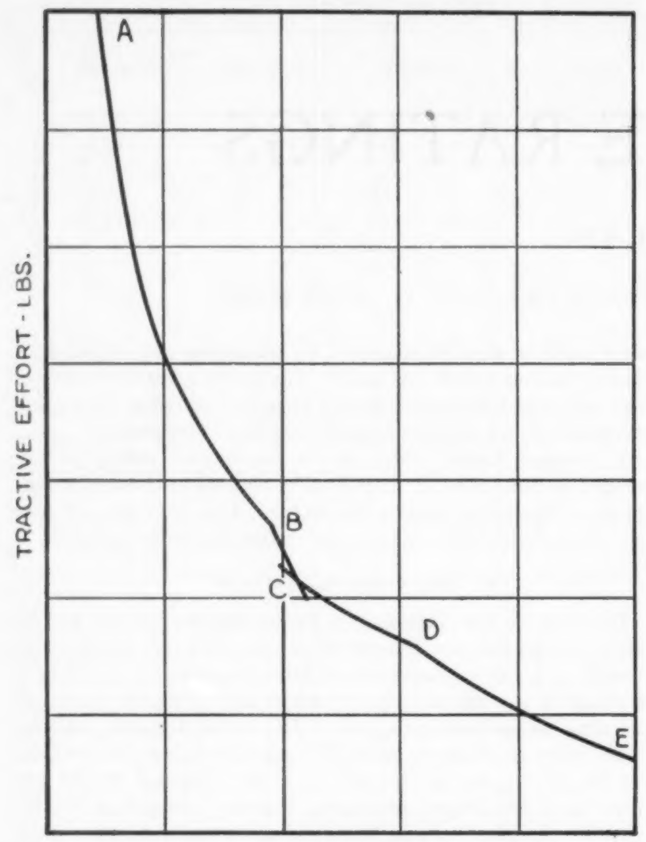

FIG. 1 DIESEL-ELECTRIC LOCOMOTIVE TYPICAL TRACTIVE-EFFORT-SPEED CURVE

an important influence. The effect of heating is not immediate. Insulation gradually deteriorates with time, and the higher the temperature, the faster the deterioration. It is therefore usual to establish a "normal" temperature limit for electrical equipment, and also a peak value which may be reached occasionally without excessive deterioration of insulation. If peak temperatures are high enough to melt solder, damage to the equipment may be rapid and serious.

The principles governing heating of electrical equipment are explained in detail in Standards of the A.I.E.E.[1]

It will be seen that Diesel-electric locomotives must be used according to instructions and within limits specified. Too high a tractive effort for too long a time will result in overheating and deterioration or damage. One object of rating the equipment is to determine in what classes of service the locomotive can safely be used.

TRACTION-MOTOR RATINGS

Traction motors, tested under A.I.E.E. Standard No. 11, may have three classes of rating: (*a*) continuous, (*b*) one-hour, (*c*) thermal capacity. It is usually unnecessary to determine both the continuous and one-hour ratings, the former being almost universally used particularly for ventilated motors and the latter chiefly useful for totally enclosed motors. In brief, the continuous capacity is the shaft-horsepower output which can be carried for an unlimited period on stand test at rated voltage without exceeding specified limits of temperature rise, for example, 120 deg C measured by resistance of armature windings. The one-hour rating is the shaft-horsepower output which can be carried for one hour on stand test, starting at room temperature, without exceeding the specified limits of temperature rise. The thermal-capacity rating is the average time in seconds per degree C for the motor to rise in temperature approximately 60 deg C (100 to 160 C) to the peak allowable temperature with a current of 1.6 times its continuous rated current (under specified test conditions see Appendixes 1 and 2).

Traction-motor-characteristic curves show tractive effort, speed, and efficiency plotted against current. These curves are at full rated voltage. It is not necessary that the traction motors should have the same power rating as the Diesel engine. The Diesel-engine power represents the maximum which the locomotive can produce, while the necessary traction-motor-power rating more nearly reflects the motor heating. It is very important that the motor heating should not be excessive due to too great a tractive effort for too great a time.

A measure of motor heating in service can be obtained from road tests carefully performed and analyzed, or it can be estimated approximately from elaborate stand tests on motor-heating and cooling curves, which can very seldom be justified.

The usual measure of motor heating is based upon the continuous (or one-hour) rating and on the short-time thermal-capacity rating. It is often convenient to express these in terms of per cent locomotive adhesion. Thus if the continuous motor rating corresponds to a total tractive effort equal to 12 per cent of the static weight on drivers, the locomotive would be said to have its continuous rating at 12 per cent adhesion. Similarly, if the thermal-capacity rating corresponds to a total tractive effort equal to 20 per cent of the static weight on drivers, the thermal capacity, in seconds per degree, gives a rough measure of the time for which the locomotive can exert this high tractive effort without exceeding the allowable peak motor temperatures.

THE TRACTION GENERATOR

The traction generators, tested under A.I.E.E. Standard No. 11,[1] may have two classes of ratings: (*a*) continuous, (*b*) thermal capacity. These are similar to the motor ratings except that the continuous rating is expressed as power delivered at any voltage from the maximum to the voltage corresponding to the maximum continuous rating. For thermal capacity, the generator is loaded to full rated power at 50 per cent of rated voltage (the rated voltage is the maximum at which the generator can absorb the full input of the Diesel engine continuously). It will be evident that generator heating may limit a locomotive in the same way as motor heating.

The electric transmission, in its simplest form, consists of a generator coupled to the Diesel engine, driving a motor coupled to a locomotive axle. By changing the generator field exciting current, the generator can produce a wide range of voltages and currents and can therefore drive the motor over a wide range of speeds and tractive efforts. In practical applications, there may be several motors and generators, and the exciting current is limited by automatic control, so that the generator will not try to take more power than the Diesel engine can produce.

In Fig. 2, *ABCDE* represents the curve of volts against generator current in amperes for a constant speed and a constant setting of the field-excitation control. The lower curve *BC 'D* represents the limit above which the Diesel engine will be overloaded. The load-regulation control must therefore be adjusted to hold as nearly as possible to the curve *ABC'DE*. The calculated generator volt-ampere characteristic must be checked by test to be sure that adjustments have been properly made. From this generator characteristic and from the motor characteristic curve, determined by test, it is easy to calculate the locomotive characteristic curve of "tractive effort" against "speed."

DIESEL-ENGINE POWER

The testing of a Diesel engine in the shop is in the nature of a preliminary check on the engine alone. Actually, the final

[1] See "Introduction to A.I.E.E. Standards: General Principles Upon Which Temperature Limits Are Based in the Rating of Electric Machinery and Apparatus, A.I.E.E. No. 1," June, 1940; also, "American Standard for Rotating Electrical Machinery on Railway Locomotives and Rail Cars, Etc., A.I.E.E. No. 11," March, 1943.

testing generally occurs after the engine has been assembled with the generator and placed on the locomotive. The object of that test is to obtain a predetermined generator curve similar to *ABC'DE* of Fig. 2, which actually determines the output of the locomotive at the wheels. The engine must have power not only to meet this curve, but to handle all auxiliaries and have at least a slight surplus. Furthermore, this output may be on a continuous basis or a short-time basis, depending upon the service in which the locomotive is engaged. Therefore, the service must be analyzed before the final loading on the engine can be determined.

DETERMINING SERVICE FOR DIESEL-ELECTRIC LOCOMOTIVE

There are two methods of determining the service for which a Diesel-electric locomotive is suited. The first is by means of road tests and the second by calculation. The road tests are made by putting the locomotive in the service in question, carefully recording the speeds, train weights, etc., and measuring the temperatures of the equipment. This indicates directly whether the locomotive is loaded correctly up to its limit. If it is not, the necessary change in loads can be estimated and, if necessary, checked by further tests. This method is simple in principle but may be difficult and expensive to carry out in practice. It gives a result only for the particular service tested and it cannot, of course, be used before the locomotive is built. The method of road testing is therefore usually confined to checking calculations, in cases where enough locomotives are involved to justify the time and expense.

The method of calculation may be carried out with varying degrees of refinement. The first step is to select train weights, and to calculate the speed-time-distance-current curves for the services involved. The square root of the mean square of the current (rms current) is a rough measure of heating and may be compared with the continuous rated current of the transmission. The peak temperatures may then be roughly estimated from the peak currents and the thermal-capacity rating, as shown in Appendix 2.

For heavy service, the Diesel engine has a continuous power rating, which it should be able to deliver without smoke, undue heating, or excessive maintenance. The engine cooling system should be able to maintain water and lubricating-oil temperatures within specified limits on a similar continuous basis.

At the other extreme, for light service, which is represented by much industrial switching, the Diesel engine may have an intermittent power rating which means that it can operate on a cycle of 30 min at full load, full speed, followed by 30 min at 50 per cent load, repeated a number of times without undue heating or smoke. Engines restricted to light service, however, must operate with a service load factor of not more than 50 per cent if they are to give reasonable service, Table 1.

TABLE 1 PERMISSIBLE SERVICE LOAD FACTOR AND RATING

Type of service	Maximum load factor, per cent	Rating
Heavy	100	Continuous
Light	50	30-min

It should be emphasized that the load factor alone does not determine the service, for example, if a switching and transfer locomotive operates on 16 per cent average load factor, but has an occasional heavy drag of full load for about 60 min, it would require a heavy service rating, since the time at full load would be limiting.

Having once determined whether the engine is to be on a short time or continuous basis, final tests can be made. The ratings of each of the auxiliaries must be determined. These include the radiator fans, traction-motor blowers and ducts to the motors, air-brake compressor, and auxiliary generator with its various loads. These auxiliary-generator loads include power to charge the battery, for the fuel-transfer pump, control circuits, lighting, excitation, electrical boiler circuits if any, and other miscellaneous auxiliaries as windshield wipers, etc. The power to operate these all come from the engine and must all be accounted for.

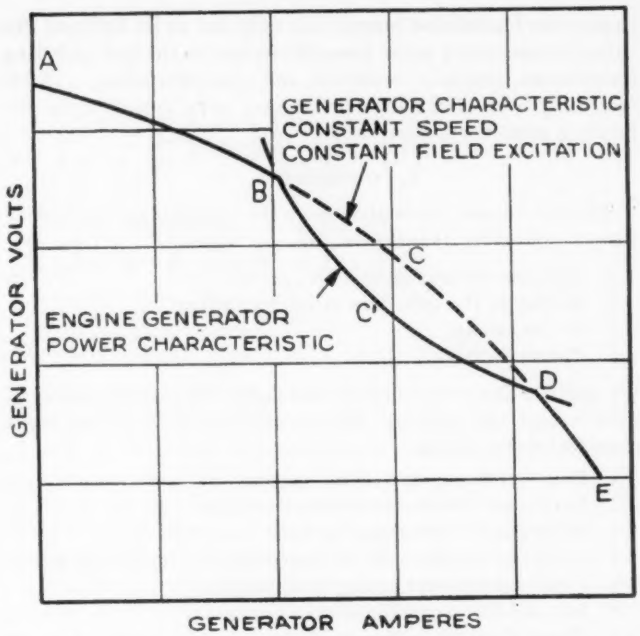

FIG. 2 DIESEL-ELECTRIC LOCOMOTIVE TYPICAL GENERATOR CHARACTERISTIC CURVES

Adding all these auxiliaries to the power delivered to the main generator, gives us the gross output of the engine. Even though the output to the main generator is continuous, as outlined, due to service conditions, the auxiliary load will not necessarily be continuous, which means that the gross output may vary as much as 7 per cent.

Therefore with all these variable percentages added up, we find the actual engine output may differ considerably from the factory rating which is generally quoted in round numbers to indicate the approximate engine output, either gross or for traction.

It has been mentioned that the output of a Diesel engine varies with many external conditions. Engines are often rated at 60 deg F and 29.92 in. Hg pressure, but for some classes of locomotives the basic rating has been considered to be at 90 deg F and 27.8 in. Hg pressure, in order to cover a greater range of conditions. Greater unification of practice is desirable.

The indicated engine horsepower is seldom referred to but, of course, is there and must be considered by the builder. The indicated horsepower of the steam locomotive is one of the few means of determining the rating of a steam locomotive so it has to be used. However, as there are so many places on the Diesel locomotive to obtain ratings, it is preferable to use one of the more tangible ratings and one nearer to the drawbar.

THERMAL RATING

Thermal input may also be considered a locomotive rating. We normally refer to a locomotive as having a consumption of so many gallons of fuel oil per hour. We should, however, refer to so many Btu burned per hour with the proper correction factors used. From this rating, we obtain the thermal efficiency. When determining such a locomotive rating of Btu per hour, consideration must be given as to how many auxiliaries are functioning and whether a train heating boiler is also included. Incidentally, the boiler rating is an important percentage of the thermal rating.

It is possible for a Diesel locomotive to be operating at a certain output and then take on board a new load of fuel oil having a higher or lower Btu value. This additional fuel oil may

change the locomotive output, not only due to its different Btu value but also many other possible changes in the fuel including temperature, viscosity, sediment, and ignition quality. Therefore the power of the locomotive may vary considerably depending upon the fuel oil used.

CONCLUSION

While the steam locomotive has only four ratings all of which vary considerably as follows:

1 Drawbar ratings at various speeds.
2 Rating at the cylinders in tractive effort.
3 Boiler rating.
4 Thermal rating.

We find the Diesel locomotive has eight ratings which vary to some extent individually, while collectively there may be a considerable variation:

1 Drawbar rating at various speeds.
2 Rating at the wheels in tractive effort.
3 Rating at the generator in volts and amperes.
4 Rating at engine shaft to main generator in horsepower.
5 Gross horsepower rating of the engine.
6 Indicated horsepower at the cylinders.
7 Thermal rating in Btu per hour.
8 Plus a heating-boiler rating, if used.

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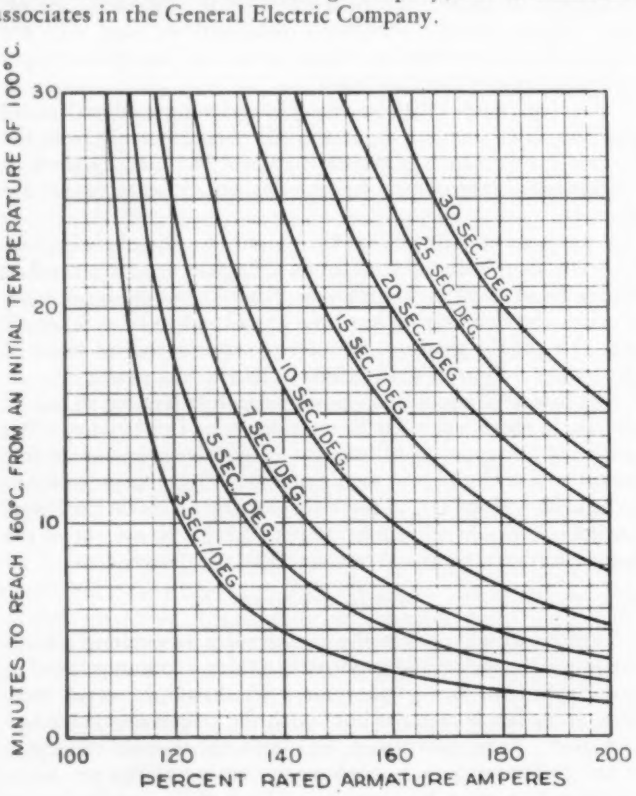

FIG. 3 ARMATURE SHORT-TIME HEATING CURVES

(Blown machines rated for 120 C rise by resistance. In order to use this chart, two A.I.E.E. ratings are required: (1) continuous armature rating (A.I.E.E. No. 11) amperes; (2) thermal-capacity rating armature[2] (A.I.E.E. No. 11 appendix No. 1)—in seconds per degree. Use the curve corresponding to the thermal-capacity rating of armature.)

[2] Quoted rating not limited by armature in all cases.

Appendix 1

THERMAL-CAPACITY RATING OF A TRANSMISSION

The thermal capacities of motors and generators are expressed in seconds per degree and represent the average rates of heating between 100 deg C and 160 deg C under a particular overload current. In order to obtain a composite rating, it is necessary to be able to convert ratings from one current to another. Fig. 3 provides a series of curves which can be used for approximate conversions. Their use is best shown by an example. Suppose we have a locomotive in which a traction generator rates full engine horsepower continuously from 750 v 940 amp to 510 v, 1350 amp. The thermal-capacity rating will be at one half the maximum rated voltage, that is, at $750/2 = 375$ v, at which the current is 1800 amp.

Suppose the thermal-capacity rating is 30 sec per deg at this current. Now consider the traction motors, connected four in series across the generator. They have a continuous rating of 830 amp per motor, so that the thermal capacity will be at $1.6 \times 830 = 1330$ amp. Here the generator will carry the motor overload continuously, and it is clear that, for short-time overloads, the motors will be limiting and not the generator.

Suppose that the motor thermal capacity is 20 sec per deg, and that we are interested in a short overload during which the locomotive exerts 25 per cent adhesion, which requires 1500 amp per motor. This is 181 per cent of continuous rated current, and the curve in Fig. 3, which is labeled 20 sec per deg, shows that at 181 per cent of rated amperes, it takes 13.7 minutes to reach 160 C starting from 100 C. This gives a direct indication of about how much overload the locomotive will stand and may be expressed as a locomotive thermal-capacity rating at 25 per cent adhesion of 13.7 sec per deg.

Now let us suppose that the motors, instead of being in series, are connected in two parallel circuits, so that the generator must take twice as much current as any traction motor. At 25 percent adhesion, the generator would be required to take 3000 amp which would be far beyond its capacity. At 15 per cent adhesion, the motor current would be 950 amp, while the generator current would be 1900 amp. The motor current is 114.5 per cent of rating, and Fig. 3 shows that the motor thermal capacity under these conditions would probably be over 1 hr. Now if the generator has a test thermal-capacity rating of 15 sec per deg at 1800 amp which is 133 per cent of continuous rating, Fig. 3 shows a capacity of 11.5 sec per deg at 141 per cent of continuous rating (1900 amp). In this case, the generator would be limiting and the thermal-capacity rating of the locomotive at 15 per cent adhesion and with motors in parallel would be 11.5 sec per deg.

It will be evident that the rating of the transmission will vary with the motor connections and may also be complicated by the shunting of motor fields. In many cases, however, motor combinations are arranged so that, for all practical purposes, the only short time limit is due to heating of traction motors in the low-speed connection. It may sometimes be necessary to check heating of generator fields in cases of sustained high generator voltage and corresponding high locomotive speed. Besides the standard method of short time rating, as given by the A.I.E.E.,[1] other methods are used, generally to simplify testing procedure, but in all cases, similar methods of prorating and co-ordinating test ratings can be developed.

Appendix 2

THERMAL-CAPACITY RATING

In many service applications of a Diesel-electric locomotive, the limiting condition can be approximately represented by a moderate load of fairly long duration, followed by a heavy load for a short time, after which the load drops and allows the equipment to cool. Such a condition is represented by the

(*Continued on page 182*)

Some Principles of the SHEWHART METHODS *of* QUALITY CONTROL

By W. EDWARDS DEMING

BUREAU OF THE CENSUS AND BUREAU OF THE BUDGET

WHAT THE STATISTICAL METHOD DOES

NOT how much product, but how much *acceptable* product, is what counts. Rejections and reworked material represent not only direct losses in manpower and material, but often far greater indirect losses, more difficult to evaluate, arising from dislocation of plans through failure to meet schedules. Industry is called upon to take advantage of every available facility for increasing the monthly output of acceptable product.

Just as mass production and the interchangeability of parts forced the use of tolerances many years ago, so it is now that demand for conformance to tolerances, and extreme demands for conserving time, manpower, and materials, are forcing the use of the statistical method in manufacturing and inspection. The statistical method in a quality-control program can be made a potent factor in meeting these demands, because it has the effect of

1 Increasing the safety and performance of product, at the same time often greatly.

2 Decreasing the amount of inspection required in many operations, yet attaining better quality assurance.

3 Decreasing the production of defective material by attaining greater uniformity at a safe distance from the tolerances.

4 Giving early warning on changed conditions of manufacture that may cause trouble or require increased inspection.

5 Improving vendor-purchaser relations by providing better records.

6 Providing a rational basis for setting tolerances with regard to requirements in service, and economies of production.

I shall attempt to say something regarding these points in the succeeding paragraphs.

First, however, let me predict that the extra exactness and uniformity accomplished for war production is not going to be lost when peace comes. The statistical method will be in even bigger demand for peacetime production.

A WORD REGARDING THE INSPECTION OF CRITICAL ITEMS

One of the most important contributions of the control chart is that it shows how much inspection is really needed. The control chart may point to more or to less inspection than you are now carrying out on some operation of your own, or on some vendor's product. Whichever it is, you will have greater quality assurance and greater safety because of the application of statistical methods.

This brings me to a word on the production of critical parts, where a single failure to meet specifications must not be permitted to occur. Here the control chart is especially needed. I would not try to talk anyone out of performing 100 per cent inspection: the responsibility is too great. But I do say that unless and until the production of a critical item is analyzed statistically, you cannot be sure that 100 per cent inspection or any other per cent is enough. You cannot put quality into a product by inspecting it. Theoretically, it may seem as if you could separate the bad from the good, but practically it just does not work out that way. One reason is that inspection is never perfect—too often it is far from perfect. Inspection is particularly not dependable when defects are rare; the fewer there are, the greater the proportion not discovered in inspection. Hence in the manufacture of a critical part (when it is to be hoped that defects are rare), if any defects are made, some of them are sure to get through. Isn't this what happens? The only way to get a critical dimension right, and to know that it is right, 100 per cent, is to know that it is being made at a safe distance from the required tolerances in the first place. The only way to know this is through knowledge of the manufacturing and testing, and through statistical control of important stages of the process. Inspection is then used—yes; not for sorting, but for assurance that the required quality is being maintained. The control chart will tell how much inspection is needed. Get the method of production right, and you will have no fear of your purchaser's inspection.

UNDERLYING PRINCIPLES—DIFFERENT KINDS OF VARIABILITY

All things exhibit variability. People and peas vary. Not all people like the same things or do equally acceptable work, or work best under any one set of conditions or hours. Moreover, the performance of any one person or machine varies from hour to hour. It follows that the quality and dimensions of your product vary from hour to hour, piece by piece, lot by lot. It will always be so. How much variation can you take out and how much improvement can you achieve without making some expensive change in your equipment or raw materials? Do you need to change the process to get the quality that you want, or can you achieve some improvement in what you are now doing? The control chart helps to answer such questions.

There is no such thing as constancy in real life. There is, however, such a thing as a *constant-cause system.* The results produced by a constant-cause system vary, and in fact may vary over a wide band or a narrow band. They vary, but they exhibit an important feature called *stability.* Why apply the terms *constant* and *stability* to a cause system that produces results that vary? Because the same percentage of these varying results continues to fall between any given pair of limits (such as the control limits in Fig. 1) hour after hour, day after day, so long as the constant-cause system continues to operate. It is the *distribution* of results that is constant or stable. When a

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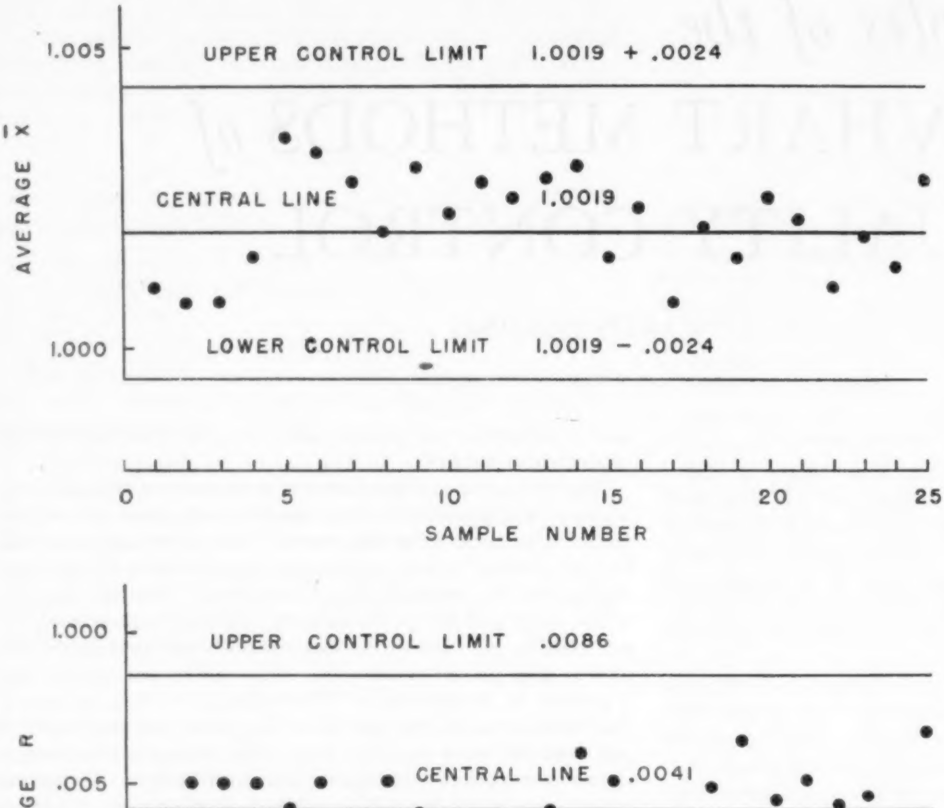

FIG. 1 SHOWING CONTROL CHARTS FOR 25 SUCCESSIVE SAMPLES, FOR A PROCESS THAT HAS BEEN BROUGHT INTO STATISTICAL CONTROL

(The upper panel is the chart for the averages $\overline{X}$, and the lower one is for the ranges R. Each sample here happens to consist of five articles, and for each sample the average and range are plotted. The range in any sample is the difference between the smallest and largest of the five measurements. The central line on the chart for averages is simply the average of the 25 averages, and the central line on the chart for ranges is simply the average of the 25 ranges. The average range multiplied by 2.114 gives the upper control limit on the chart for R, and the same value multiplied by 2×0.577 gives the separation of the control limits on the chart for $\overline{X}$. These constants are easily determined from tables. No points fall outside the control limits on either chart, and there are no suspicious looking patterns. The control charts thus show no evidence of lack of control. Stability of the distribution of the measurements for this particular method of manufacturing, sampling, and testing may be assumed; and advantage may be taken of the state of control as outlined in the text.)

manufacturing process behaves like a constant-cause system, producing inspection results that exhibit stability, it is said to be in *statistical control*. The control chart will tell you whether your process is in statistical control; I shall return to this soon.

The easiest way to construct a constant-cause system is to draw numbers from a bowl. Suppose you write a number on each of some physically similar and carefully made poker chips; put the chips in a bowl, shuffle thoroughly (thoroughly, I said), then draw five at a time for the first sample; put them back, shuffle, and draw five more for the second sample; etc. Each sample of five numbers has a mean (or average), and a range (difference between the smallest and the largest number of the five). The means of the samples, and their ranges, will vary from sample to sample, but these variations will exhibit stability or statistical control. That is, when the means and ranges are plotted in order of production on a control chart (Fig. 1), the points will fall within the control limits and exhibit no suspicious looking patterns, i.e., if you shuffle thoroughly.

Now here I wish to point out something important in connection with the desire to attain a better quality level, or greater uniformity. Look at Fig. 1, and imagine that you wish to raise or lower the level of the control limits, or to change their spread. To do so you must make a fundamental change in the process; you must make up a new bowl by changing the numbers on some of the chips, or by creasing or scoring some of them, or by failing to shuffle thoroughly. Likewise, when a manufacturing process is in statistical control, and you wish to change the general level of quality, or to narrow the spread of the variations, you must make a fundamental change in the process. This fundamental change might be only a simple adjustment of a machine, or the installation of some shims under a mold; it might be an educational program for the operators; again, it might be something more formidable, such as new machinery, which might be unthinkable; it might be different specifications for the raw materials used, or something else.

An important feature of statistical control is that when you have achieved it, i.e., when your inspection results behave as if they were numbers being drawn from a bowl, you should not try to discover why one lot is better or worse than another; it will not pay. You will have no more success than you will if you try to discover why one sample from the bowl is different from another. This is difficult to comprehend. I ought to repeat it over and over. You must look for assignable causes only when the control chart shows lack of control (Fig. 2).

Last summer I visited a great corporation in which the president was always anxious whenever the amount of scrap was greater one day than it was the day before. Now of course it is well to get interested in scrap, and the control of scrap incidentally offers an important use of the Shewhart control chart; but if one looks for trouble in the plant every time the amount of scrap is higher one day than it was the day before, as this man did, he will be looking for trouble far too often. It costs money to look for trouble. The amount of scrap is going to vary day after day even under controlled circumstances.

TWO PROBLEMS ALWAYS PRESENT

Two problems are always present in the production or purchase of materials:

Problem A. What to do with *this lot*? (Accept it, reject, pass, scrap, rework, regrade, or further inspect it before deciding which to do.)

Problem B. What to do with the *process*? (Leave it alone; or look for some identifiable cause, make some adjustment, use different raw materials; carry out more or less inspection than you have been doing on previous lots.)

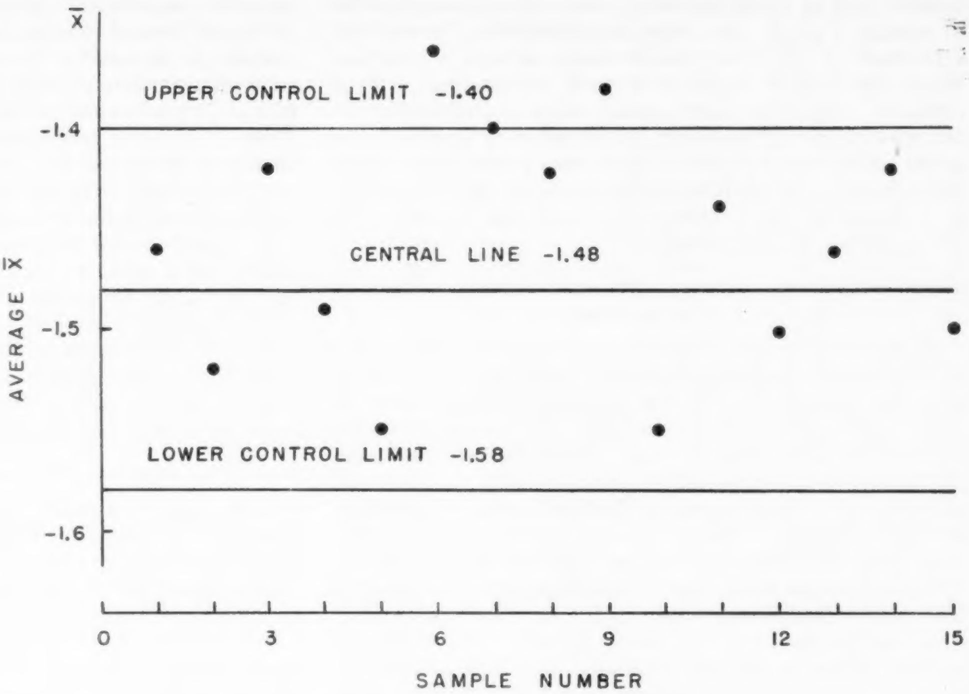

FIG. 2 SHOWING LACK OF CONTROL

(Lack of control is shown by the fact that samples 14, 15, and 16 fall outside the control limits, indicating the need for action on the process to find and remove an assignable cause of variation. Until the assignable cause is found and eliminated, the process must be considered out of control. The product will show more variability than necessary. Spotty conditions will exist, and sufficient inspection will be required to provide quantitative information adequate in itself to serve as a basis for action regarding the disposal of the product lot by lot.)

Both these problems are always present, whether you are manufacturing or purchasing, I say, and action, intelligent or otherwise, is continually being taken one way or another, lot by lot, hour by hour. The control chart helps to formulate rational courses of action by showing when the variations in the inspection results may safely be left to chance, or whether it will pay to assume the existence of an assignable cause and do something about it.

TWO KINDS OF MISTAKES

Now in acting on these problems, you can make two kinds of mistakes. We should be thankful that there are only two. The question is when to act as if there were an assignable cause, and when not.

If you look for trouble or increase the amount of inspection because you think there is an assignable cause (one you can find) when actually none exists, you will only go on a wild-goose chase, waste time and money, and probably make trouble. Also when you fail to look for trouble or to recognize a spotty condition arising from an assignable cause when one actually exists, you waste time and money again. We might say, then, with Shewhart, that there are two kinds of mistakes occasionally made in any quality-control program:

1 Looking for an assignable cause of variation or increasing the amount of inspection, when the variations in quality are only random.

2 Failing to look for an assignable cause of variation or failing to increase the amount of inspection, when an assignable cause actually did exist.

We must expect to make these mistakes once in a while, even when using the statistical method, but we try to keep their costs at a minimum. The Shewhart control chart was designed to answer the question, when to look for an assignable cause, by striking an economic balance between these two kinds of mistakes.

HOW THE CONTROL CHART WORKS

Points are plotted on the control chart from the hourly or daily inspection results. Each point corresponds to a supposedly homogeneous batch of product, or a sample thereof. The plotted points will show variation in quality from one batch to another. These variations may indicate assignable causes or not. It depends on their relation to the control limits.

Control limits are placed on the chart. The rules for placing them are astonishingly simple, but I cannot stop now to explain; instead I refer you to the literature cited further on. The control limits provide a criterion for action. They strike an economic balance between the two kinds of mistakes mentioned at the close of the last section. When a point falls outside them, it will pay to assume that some assignable cause produced the variability. You will try to discover the cause and eliminate it if practicable. You will plot each point as soon as possible after the inspection results are obtained, to be advised and be in position to take action as early as possible. Whether you are buying or manufacturing, lack of control indicates a spotty or variable condition and the need for increased inspection to maintain protection.

On the other hand, after you think all assignable causes have been eliminated, if a sequence of 25 or more points on the control chart stays inside the control limits and exhibits no suspicious looking patterns, the variations in quality should be left to chance; you will probably only bring on trouble if you try to discover why the quality varies. Of course, you might wonder why the general level or spread is so far from what you want or a redefinition of what you want (change in specifications), but this is a different story, requiring a fundamental change in the process, not a hunt for assignable causes.

We are now ready to appreciate the power of the statistical method to give us greater quality assurance by bringing about the state of statistical control. If we draw from a bowl, every sample gives us more information about future samples, in the sense that it helps us to attain greater accuracy in setting limits within which 99 or any other per cent of future samples from this bowl will fall. So it is when the production process shows statistical control: the lots of product, hour after hour, are then in effect drawn out of the same bowl; and with every sample we are better able to predict the quality of untested samples, whether of product already made or yet to be made by this same process. Information accumulates with every sample, however small.

On the other hand, when there is poor control, the situation is as if someone busied himself by changing the bowl between samples. Successive samples would not give more information about any one bowl, because every sample comes from a different bowl. To learn more about any one bowl, we should need to draw more samples from it. That is why, in poor control, one needs to take bigger samples and do more inspecting. Each lot stands by itself, i.e., you don't know anything about it from knowledge furnished by other lots.

Ordinarily, the state of statistical control is not easy to

achieve; it is an accomplishment, often at the expense of weeks or months of effort. But every step accomplished toward the attainment of statistical control brings savings in time and money and cost of inspection to both the producer and the consumer. Often the control-chart record of production foreshadows impending trouble. A downward or upward trend of the points, or some other pattern, may indicate that unless corrective measures are taken (such as a change in raw materials, or a change in heat-treatment), an inordinate amount of defective product will be produced.

SAFETY AND ECONOMY BOTH REQUIRE SPECIFICATIONS IN TERMS OF A DISTRIBUTION

Think of a piece part that is going to be put into production with an outside diameter of one inch. One inch. Now what does this mean? That all the pieces are to have their OD equal to one inch? Exactly one inch? Let the answer be yes if you don't really mean one inch. If the diameter need only be close to one inch, it would be quite sufficient to say one inch and forget it. The diameter of the handle of a broom might be a good example. The handle does not fit into any other part, except the hand, and the dimension need not be close.

But suppose the part is one on which the dimension must be held close. Then do we mean exactly one inch? No. After a few hundred parts have been made, no matter how much care has been taken to achieve uniformity, it will be found that there is a largest and a smallest diameter, with the others scattered between. Most of them are usually crowded toward the average, with progressively smaller proportions within intervals to the right and left of the average. In other words, there will be a *distribution* of the measurements, extending from the smallest to the largest. We are forced to the paradox that the more critical the requirement for a diameter of one inch, the surer we are that we must not specify exactly one inch. The pieces cannot all be made alike, and, we need to know that their diameters are. We accept these facts and place tolerances on the dimension. The concept of tolerances was once new. It seems entirely natural and acceptable to us now, but it was not so in the beginning. Mass production and the interchangeability of parts forced it.

What is meant by a tolerance of 1 ± 0.002? Must *all* of the diameters fall within this interval? or is it satisfactory if 98 per cent of them do? or 90 per cent? In order to avoid needless and costly refinement, the specifications should state the lowest percentage that will suffice. One hundred per cent conformance should not be specified if 98 per cent will do. It is not enough to specify the tolerances: it is necessary also to specify how much of the product is expected to conform. If 100 per cent conformance to tolerances is required, it is necessary that

1 The distribution of diameters be stable, hour after hour.
2 The largest and smallest diameters in the distribution lie at safe distances from the tolerances.

If only 90 per cent conformance is required, the distribution must again be stable, but now, 10 per cent of it is allowed to go beyond the tolerances. For economic production, the manufacturer must get all of this 10 per cent; he is not paid for refinements beyond what is specified.

But how can either the maker or the purchaser know what percentage conforms? The control chart is the answer. Thus, whether the demand is for accuracy, or for economy of time, manpower, or materials, one is forced to deal not only with tolerances, but also with the distribution of quality in relation to the tolerances, and evidence that this distribution is stable. These are some reasons why the statistical method is assuming so much importance. In time, the concept of a distribution and the statistical method of control will seem as natural as a plus and minus sign in a specification, signifying tolerances.

The purchaser pays for wasteful production, for the manufacturer's inspection and for his own; and to keep costs down he should demand process control and evidence thereof. The evidence is contained in the control-chart record of important steps of the manufacturing process. Such charts should be part of the product and should be called for in the specifications. There is no other arrangement so satisfactory for either the vendor or the purchaser. Of course, the purchaser may still need to do some testing on his own gages and in his own way, but this can often be cut to a trifling amount.

Statistical control and the control-chart record are especially needed for a product that can be tested only by destructive testing. If the important steps of the manufacturing process are in statistical control, the quality of untested product can be inferred from the samples that are tested. Without statistical control, no such assurance is possible. The more critical the product, the greater the need for statistical control, and the evidence furnished by the control-chart record.

GROUNDS FOR CHANGING SPECIFICATIONS

When there is difficulty with the specifications, statistical control of the process furnishes grounds for deciding whether to change the process or the specifications. As stated earlier, a fundamental and possibly expensive change in the process is required for effecting a change in the level or the spread of the distribution of the product, to place it more in line with the specifications.[1] The only alternative is to adopt other specifications, more in line with the distribution actually being produced, to allow more material to pass inspection. Whether these other specifications would serve the purpose intended for the product, is of course another matter. The decision lies between changing the specifications, or incurring the cost and loss of time accompanying the fundamental change in the process. One or the other or both is required. Without statistical control, no distribution exists and there is no basis for arguing that some costly change in the process is required for meeting the present specifications.

THE RESPONSIBILITY OF MANAGEMENT

In application, the statistical method of control is easy—astoundingly so. One can actually learn to transform his data into control charts in a few hours. Only simple arithmetic is required, and the ability to plot points on a chart. In eight solid days one can acquire sufficient facility to proceed with his own problems. The simple statistical procedures which you can learn so easily are the cream of many years of mathematical and industrial development. You need not be a mathematical statistician to do good statistical work, but you will need the guidance of a first-class mathematical statistician. A good engineer, or a good economist, or a good chemist, already has a good start, because the statistical method is only good science brought up to date by the recognition that all laws are subject to the variations which occur in all nature. Your study of statistical methods will not displace any other knowledge that you have; rather, it will extend your knowledge of engineering, chemistry, or economics, and make it more useful.

Without the use of statistical methods in your quality-control program, all is not being done that should be done to improve the quality of your product and to make it cheaper and quicker. Don't wait till your competitor teaches you these things. The experience of some of the great corporations in this country is not to be ignored. But do not assume that statistical methods can be used only in the great corporations. Do not assume that because you have a small company or make only a few models of a kind you do not have mass production. Mass production in the usual sense is not necessary. If you have people or machines in a continuing operation, such as

[1] The reader may profitably turn to Fig. 2 on page 14 of the 1942 American War Standard, cited in a later section. An article by Sir Charles Darwin, "Statistical Control of Production," in *Nature*, May 23, 1942, should also be read in connection with this paragraph.

teams of riveters, or welders, though they make only one model of a kind, they are in mass production, and the control chart will disclose some unsuspected characteristics in the variation of these processes. Some of the testimonials that I could tell you about have come from small companies; some have come from companies that have made statistical analyses of tests carried out on only a single model; the more expensive the model, and the more critical the demands on its performance, the greater the need for statistical analysis of the tests before embarking on the manufacture of another one.

NEW USES

New uses of the control chart are continually being found. William Rice[2] recently made an application in the field of overtime work. It was found in his company, as it may be in yours, that in some departments the amount of overtime work required was out of line with the others—out of statistical control. Causes were found and eliminated, and the points came back the next month within the control limits, with considerable savings in time and money.

An ingenious modification has been achieved lately in the Bureau of the Census by Forrest E. Linder and Theodore Woolsey, who adapted sampling and the control-chart technique to the quick publication of monthly death rates by cause of death, so that epidemics can be discovered and their course followed, and early remedial action taken.

The control chart can be applied to test the uniformity and adequacy of check inspection; to flaws in welding and riveting. It can be applied to the inspection of finished assemblies; time lost through lack of backlog; discrepancies in inventories and accounting. It is the only satisfactory solution to the standardization of machine performance; standardization of testing instruments; standardization of foods and drugs; personnel placement; standardization of personnel performance; setting piece rates. Half a million dollars were saved through the application of statistical control in the clerical work of processing the returns of the 1940 Census in the Washington office,[3] with better assurance of standards of quality. I dare say that during the next few months some more unheard of applications will be made.

CONCLUSION

The statistical part of a quality-control program, however important, is only part of the program. The rest of the program includes good engineering control of the process; training of the personnel, both operators and inspectors; frequent review of the sampling and test procedures, with careful first-hand checks on actual performance; frequent calibration of instruments and gages. The rest of the program must function well, or the statistical part cannot be effective. The statistical method cannot be expected to make good data out of bad. Data that cannot be used should not be taken. Data that cannot be used on a control chart are of doubtful validity except possibly for accounting purposes. It is up to the quality-control man to see that the sampling and other procedures yield data that are useful in driving toward desirable quality goals. He must not get so thrilled with his charts that he forgets the other parts of the program. On the other hand, the quality-control man is throwing his effort to the wind if no action on the process is attempted when his charts indicate need therefor.

What is a finished product to one concern or department is raw material to another. A quality-control program must necessarily include improvement of raw material through assistance, statistical and otherwise, to the subcontractor or department that makes your raw material. In other words, quality control must be rooted deep.

Success in the use of the control charts will depend largely on using them in the right places, and on using enough charts but not too many. This means that the quality-control man must know the process well enough to suspect the most likely sources of assignable causes, and perform his subgrouping accordingly. His toughest problems, like some of yours and mine, are usually psychological—how to gain and keep the confidence of the right people. He needs willing information from operators and inspectors; he must persuade management to take action when assignable causes are indicated.

One important point concerning sample inspection is not often mentioned, so I shall bring it to your attention here. When the requirements of the product and the state of control are such that sample inspection yields adequate quality assurance, you will have a better index of quality by sample inspection than you will get by 100 per cent inspection. This is so because in sample inspection a higher proportion of the defectives is found in the material presented for inspection. One reason doubtless lies in the monotony of 100 per cent inspection. Another reason is that the testing instruments can be kept in better condition and only the upper grade of inspection personnel utilized because of the smaller amount of material to be handled.

There is a wider horizon envisaged for the professional inspection department in the future, as the statistical method is more and more required in management. This horizon will overlap the work of other departments as use of the control chart spreads from the broader functions of process control into guidance in the designing and the writing of specifications, to fixing standards of performance not only of the product bought and sold, but of men and machines, and to the placement of personnel. The control-chart record in vendor-purchaser relations is sure to attain increased importance. I do not claim to have answers to the organizational problems involved as these broader functions of the inspection department are demanded, but they will be solved in time.

LITERATURE ON THE SUBJECT

With remarkable foresight, perceiving the need for statistical methods in the strain that was bound to come in the war-production program, officials of the War Department in 1940 asked the American Standards Association to develop concise treatises describing the application of statistical methods for use in acceptance inspection and for control during manufacture. A committee was appointed to develop the treatises, and as a result of their efforts, the three American War Standards shown below were produced. They are published by the American Standards Association at 29 West 39th St., New York 18, N. Y.

1 Guide for Quality Control, 1941.

2 Control Chart Method of Analyzing Data, 1941. (Nos. 1 and 2 are bound together and sell at 75 cents.)

3 Control Chart Method of Controlling Quality during Production, 1942, 75 cents.

For further reading, the text by Colonel Simon and the other books listed below may be recommended.

4 "An Engineer's Manual of Statistical Methods," by Leslie E. Simon, John Wiley and Sons, Inc., New York, N. Y., 1941.

5 "The Economic Control of Manufactured Product," by Walter A. Shewhart, D. Van Nostrand Co., Inc., New York, N. Y., 1931.

6 "Statistical Method From the Viewpoint of Quality Control," by Walter A. Shewhart, Graduate School, Department of Agriculture, 1939.

7 "The Application of Statistical Methods to Industrial Standardization and Quality Control (600 R), by Egon Pearson, British Standards Institution, London. Recently revised by Dudding and Jennett.

[2] "Quality Control Applied to Business Administration," by William B. Rice, *Journal of the American Statistical Association*, vol. 38, 1943, pp. 228–232.

[3] "On Sample Inspection in the Processing of Census Returns," by W. Edwards Deming and Leon Geoffrey, *Journal of the American Statistical Association*, September, 1941, vol. 36, pp. 351–360.

A Practical Program for HUMAN REHABILITATION

By HAROLD A. VONACHEN

MEDICAL DIRECTOR, CATERPILLAR TRACTOR COMPANY, PEORIA, ILL.

THE return of the physically handicapped from military to civilian life presents a problem which will test American ingenuity equally as much as its economic and political problems. Unless a well-organized program is prepared in advance, we will be faced with returning disabled men being forced to wait for jobs, with each day's delay increasing their resentment, their mental depression, and the thought that they might be dependent upon charity.

About eighteen months ago, the author's company realized that 4000 to 5000 employees would return after the war with many of them suffering from physical handicaps. In facing this problem, the company could draw upon its many years of experience in the rehabilitation of its own physically handicapped. This, plus a shortage of manpower, presented the possibility of unifying our program for the civilian and military handicapped people. Steps were taken for its formation, with close co-operation between Medical, Personnel, Training, and Safety Divisions.

TYPES OF JOBS AVAILABLE FOR DISABLED

It was first necessary to determine the jobs available for these individuals, and a survey was made in which each supervisor listed the jobs in his department which could be performed by employees with the handicaps listed on the survey cards. With this information, the Personnel Division with its knowledge of "job analysis" was ready to interview each individual, and then present the applicant to the Medical Division for its approval of the specific job chosen. A personal interview followed, impressing upon the employee the necessity for care and safety in his work, and a note placed upon his record card that no transfer could be made without the consent of the Medical Division.

Supervision and training now appears in the picture. Supervision was instructed in the proper handling of these people, and then the "Job Instructor Training" given job trainers. That supervision has given its complete approval, there can be no doubt, for almost daily they are asking for more handicapped employees. They are continuously finding new jobs, and several supervisors have learned the sign language in order that they might converse with their deaf mutes. Many of our employees with physical handicaps are attending special classes given by our training school in order that they may advance in their quest of independence.

There can be no doubt that this company program has been successful, for the vast majority of these people have a production, safety, and absentee record above average. They are paid the same rate as normal individuals; they are shown no special favors, and are in no way considered as accepting charity. They will be given the same consideration as any other employee in being retained on the job in the days following the war.

CLASSIFICATION OF HANDICAPPED EMPLOYEES

It might be well to consider the classification of the handicapped. Some employers list on their pay roll many thousands of physically handicapped people, but they include in the group employees with hernias, loss of fingers, slight defects in vision, hay fever, etc. In the handicapped group of the author's company are only those with loss of one or both extremities, marked deformities, loss of one or both eyes, loss of hearing and speech, and those with healed tuberculosis, heart disease, etc.

The classification after all is unimportant, except that some uniform plan would help in the formation of a nation-wide program.

At present, the company has approximately eight hundred such handicapped employees, and this number is remarkable when consideration is given to the fact that it builds heavy machinery, calling for heavy and light machine work, similar types of assembling, and gray-iron and aluminum foundry work.

State compensation laws must be considered, and some changes would relieve the employer of carrying all the risk. Steps are now being taken in order to overcome this objection, so that more of these individuals with handicaps will be able to obtain gainful occupations.

Those suffering from nervous disorders returning from military service will present a problem of some magnitude, but certainly many of them will recover if we are able quickly to absorb them into an occupation which will convince them that they are fully capable of caring for themselves and their dependents. Days of calling upon one employer after another, weeks of disappointments and indecisions will only aggravate their condition, forcing them to accept any aid available for a livelihood. Many cases of this type will require special medical care and vocational training.

After the company had become assured of the success of this program in its plant, it was felt that the plan should be carried forward to the community. The idea was offered to the Peoria Manufacturing Association, and from this came "The Peoria Plan for Human Rehabilitation—Civilian and Military," which we believe is the first to be established in a community with a complete working organization. This plan is unique because the many employers in the Peoria area were organized and made ready to accept the physically handicapped. Usually, the intake groups are forced to approach industries and other employers with a plea for opportunities for the persons with physical handicaps.

THE PEORIA PLAN FOR HUMAN REHABILITATION

The Peoria Plan consists of an executive committee with representatives of all the interested groups in the community, American Legion, disabled American veterans, mothers' and fathers' service clubs, manufacturing groups, retailers, unions, Junior Chamber of Commerce, associations of commerce, Ministerial Association, Catholic priests, Red Cross, schools, mothers' clubs, farm bureau, federal, state, county, and city agencies.

Subcommittees were formed, and now an office is being equipped, clerical help being donated by the Red Cross. A counselor is being employed, who will first investigate cases and then confer with a steering committee which will place

(*Continued on page 204*)

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, New York, N. Y., Nov. 29–Dec. 3, 1943, of The American Society of Mechanical Engineers.

QUALITY CONTROL *in Manufacture of* SMALL-ARMS AMMUNITION

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By "quality control" we understand a method of control in which the tolerance limits are established by the reproducibility of the process or product which is being controlled. It is very nearly always expedient to establish the system so that the results are adapted to plotting on charts. The use of control charts is an extremely advantageous but not an essential feature of quality control.

Quality control can be applied either to the inspection of manufacturing processes, or to the acceptance of a raw material or finished product. The fundamental principles involved are the same for either type of control, but the detailed procedure depends to a large extent upon whether we are concerned with control of a process or acceptance of a product.

In this paper, we propose to describe the application of quality control to the process inspection of small-arms ammunition and to present some of the results obtained in this work. Very valuable contributions have been made by the Ordnance Department of the United States Army by applying quality control to the acceptance of finished ammunition. These methods and results, however, will not be here discussed.

THE MANUFACTURE OF SMALL-ARMS AMMUNITION

The sizes of small-arms ammunition of particular importance in the present war are caliber .30, caliber .45, and caliber .50. These rounds are required in large quantity by the armed forces for use in rifles, pistols, and machine guns. They are being manufactured in a number of government-owned plants which are operated by several contractors.

The manufacture of small-arms ammunition has been developed by Frankford Arsenal over a long period of years. Important contributions have also been made by the peacetime manufacturers of sporting ammunition.

Finished ammunition of the type under discussion comprises a bullet, or projectile, inserted in a brass case containing the propellent powder. At the head of the case there is inserted a primer which on impact of the firing pin ignites the propellent powder. The problems arising in manufacturing this product are for the most part those problems involved in metal-working processes. The starting material for the case is brass strip. From this strip, disks are blanked and cupped and these cups constitute the starting material for the majority of the manufacturing plants. The cups are first drawn to the desired length and diameter. It is standard practice in caliber .30 to employ four drawing operations, the first three of which are followed by annealing operations. The head of the case, including the primer pocket, is formed in a horizontal toggle press. The extractor groove is formed in the simplest type of screw machine. Finally, the case is shaped in a vertical dial press to conform to the chamber of the weapon for which it is intended.

The bullet is made similarly in that the starting point is a gilding-metal cup which is drawn to the desired diameter and length. In a multiple-station straight-line press, the bullet jacket is pointed, a core, usually of lead, is inserted into the pointed jacket, and the base of the jacket is coned over to form the base of the finished bullet. These operations may be more readily visualized by noting the progressive change in shape of the various components shown in Fig. 1. This drawing shows cross-sectional views of the intermediate components. Case components are shown in the lower line and bullet components

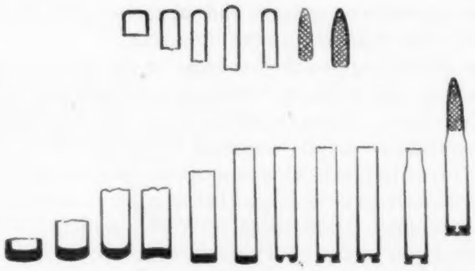

FIG. 1 PROCESS COMPONENTS SHOWN IN CROSS SECTION
(Bullet components in upper line; case components in lower line; finished round shown on right.)

in the upper line. Reading from left to right, these components proceed from the initial cups to the finished case or bullet, respectively. The assembled cartridge is shown schematically at the right.

Apart from control of the metallurgical properties of the case and bullet, and of the ballistic properties of the finished round, the most important features of the ammunition are the dimensions of the finished round. It is apparent that every cartridge must fit the chamber and mechanism of every weapon. This requires maintenance of fairly close tolerances in the significant dimensions of the finished round. In order to meet these requirements, it is necessary to maintain close control over most of the dimensions of the intermediate components, since dimensions of the finished product are determined not only by tooling at final operations, but also by incoming component dimensions. For example, excessive variation in base thickness of the fourth-draw components may cause excessive variation of primer-pocket dimensions.

Dimensional control of small-arms ammunition has been, to a very large extent, obtained by means of conventional go-no-go gages. It is, of course, customary to manufacture the product with work gages possessing smaller tolerances than the inspection gages subsequently used for acceptance.

Manufacture of small-arms ammunition by the U. S. Rubber Company is a new departure for substantially all of the personnel involved in the project. At an early stage of our training, it became apparent that a degree of control would be necessary which is not always realized in the rubber industry. It was felt that the most efficient methods available should be applied to our efforts in this new field. We therefore proposed to use quality control throughout the manufacturing process.

INSTITUTION OF QUALITY-CONTROL METHODS

Quality control had not been applied to the sizes of small-arms ammunition here discussed prior to the present conflict, although the Ordnance Department has used these methods for a number of years in the manufacture of other types of matériel.

Contributed by the Management Division and presented at the Annual Meeting, New York, N. Y., Nov. 29–Dec. 3, 1943, of The American Society of Mechanical Engineers.

The first problem in instituting quality control is one of sales and education. The fundamental ideas back of this method of control are unfamiliar to the majority of production and inspection personnel. It is necessary to secure their co-operation and support in the use of these methods in order to accomplish any useful results. We have found it expedient to carry out our sales effort at the organizational level of the men who will eventually be responsible for carrying on the control on a routine basis. This means selling one's product to a large number of production foremen and supervisors of inspection. It is a more time-consuming and laborious process than convincing one executive of the desirability of quality control but, in our opinion, is well worth the extra effort. If new methods of this type are instituted by directive from top management, we believe there would be greater difficulty in bringing them to the stage of a useful working tool in the hands of the foremen and supervisors who, in the last analysis, must obtain the primary benefits. We feel that the procedure adopted, namely, to make our main approach to foremen and supervisors, has been of considerable value in achieving our objective.

It next became apparent that most of the gaging operations customary in this industry were not well adapted to quality-control methods. One can, of course, apply these methods in many instances to results obtained by means of the go-no-go gage. This is impractical in our operation because it is necessary to maintain gaging defects below a proportion of one in a thousand or one in ten thousand. To obtain useful information from a go-no-go gage would therefore require gaging a tremendous number of components. This problem was met by substituting dial gages for go-no-go gages. Dial gages give a continuous measurement of the dimensions involved of sufficient accuracy for our purpose.

The detailed steps followed in instituting chart control of a particular dimension are as follows: A preliminary survey is first carried out by personnel trained for this purpose. A large proportion of this work is done by women with college education or the equivalent. Ability to establish and maintain satisfactory relations with operating personnel is a more important qualification for this job than prior statistical experience. At the conclusion of the preliminary survey, details such as sampling schedule, design of chart, and actual limit lines are determined. The next step is to present the material to the operating personnel in such form that they will be willing to give the method a fair trial. This involves primarily highly simplified explanations of the principles involved. Use of the standard technical terminology should, of course, be avoided in these explanations. It is, however, possible to get across the necessary ideas without too much difficulty.

An equally important point is the necessity of changing the objective of the operating personnel. Use of the go-no-go gage encourages satisfaction with components which meet the gage. Components which are close to the gage tolerances are just as satisfactory as components which are close to the mean. On instituting chart control, it is necessary to convert the operating personnel to the desire to obtain products which are as close to the desired mean as possible. In effect, the control chart gives a visible target, whereas the go-no-go gage is somewhat like shooting at a hole. It is important to emphasize this distinction.

During the early stages of instituting chart control on a particular dimension, it is necessary for the personnel who have developed the details of the particular chart to maintain close contact with the operation. This is in order to train operating personnel in the routine of the charts, to clear up difficulties and misunderstandings, and to insure accuracy and fidelity of recording.

RESULTS OBTAINED

At the present time, we control approximately twenty measurements by means of control charts. In only one instance has it been necessary to eliminate a chart. This was due to adoption of an impractical design of gage and is not to be considered a reflection on this general method of control.

The results obtained from the use of quality control will be illustrated by description of two operations where we feel outstanding advantages have been obtained.

The tapering operation, in which the case is shaped to fit the chamber of the weapon, has already been mentioned. One of the most important dimensions established at this operation is the so-called head-to-shoulder length. Fig. 2 shows in cross section the case after tapering. The head-to-shoulder dimension is also indicated in this sketch.

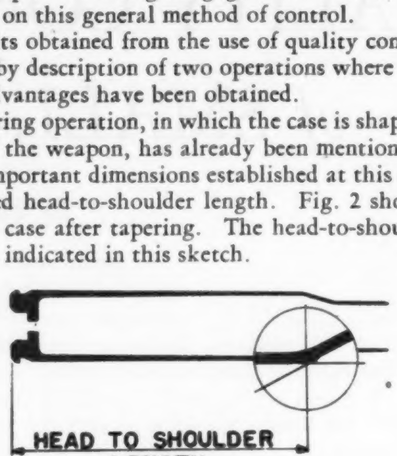

FIG. 2 HEAD-TO-SHOULDER DIMENSION OF A CARTRIDGE CASE

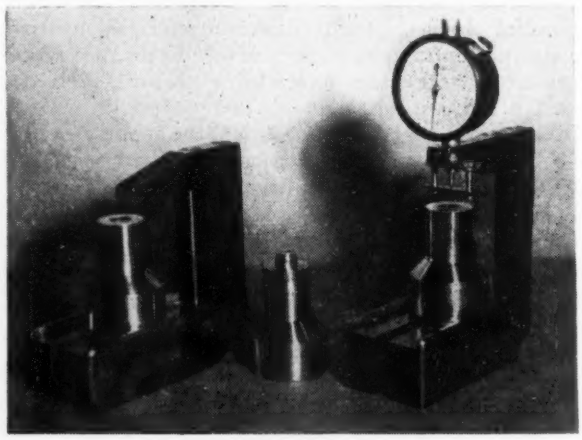

FIG. 3 HEAD-TO-SHOULDER GAGES

A number of rather difficult problems in gage design arise in this measurement, since one end of the dimension in question, namely, the shoulder end, is not well defined. These, however, have nothing to do with quality control and hence need not be discussed at this time.

The conventional type of gage used for this dimension consists of a chamber in which the case is placed. The case rests on its shoulder which is supported by a tapered constriction in the chamber. The chamber is placed on a flat surface and slipped under a snap gage of the go-no-go type. The first step in applying quality control to the head-to-shoulder length was to develop a dial gage to replace the snap gage.

Fig. 3 shows the old type of head-to-shoulder gage on the left, a receiver with case inserted in the center, and the new type of head-to-shoulder gage on the right. It will be noted that the upper arm of the original snap gage has been replaced with an arm holding a dial gage, the point of which bears upon a small plate which can move freely on two supporting pins. When a case is inserted in this gage, the movable plate is supported by the head of the case and communicates the vertical displacement to the dial gage. The gage as finally developed is shown on the right of Fig. 3.

At this point, it should be mentioned that institution of a dial gage in place of a go-no-go gage has, in all instances, been extremely popular with the operating personnel, provided the dial gage was well enough designed to give consistent results. This popularity, of course, is due to the substantially greater information obtained from a dial gage. It is more useful to the toolsetter to know where the product is in the tolerance band than to know simply that it is within the band. This advantage, of

course, has nothing whatever to do with quality control. In our program, however, we have capitalized on the popularity of the dial gage without severe damage to our consciences. Since the dial gages were instituted as part of the control-chart procedure, the entire project was given a good start because of the popularity of the gage. The resultant good effects have justified the use of this incidental advantage.

The detailed procedure for applying quality control to this particular dimension may be summarized as follows: Five consecutive components are taken from each machine at intervals of approximately thirty minutes. These components are gaged, the individual readings are recorded, and the average and range

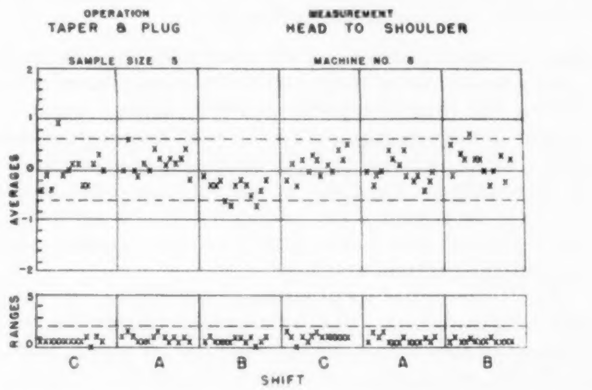

FIG. 4 CONTROL CHART FOR HEAD-TO-SHOULDER DIMENSION

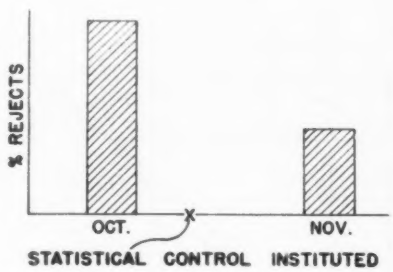

FIG. 5 REDUCTION OF REJECTS: HEAD-TO-SHOULDER LENGTH

plotted on an appropriate chart placed in a frame attached to the machine. Limit lines are drawn on the chart by the department which institutes and services the charts. At regular intervals of approximately 1 month, the average range of all machines is computed, and, if necessary, new limit lines are placed on the charts. After the system is in use, the inspection department carries out the routine measurements and plots the points on the charts. If any point falls outside the limit lines, the toolsetter adjusts the machine and a further sample is taken.

Fig. 4 shows schematically a typical chart of results obtained in control of the head-to-shoulder dimension. Units shown on the ordinate are in thousandths of an inch. The limit lines are placed at intervals of plus or minus three sigma. In this particular operation, it has been found advantageous to recognize well-defined trends, such as is noted in the second "C" shift. These are apparently associated with gradual displacement or wear of tools in the machine and can frequently be used as warnings to adjust the machine before any material has been produced outside specifications.

Unfortunately, conditions of our operation have been such as to preclude to a large extent obtaining clear-cut estimates of the improvements of quality due to adoption of chart control. This is because quality-control methods were instituted soon after the start of our operation and during a period in which operating efficiency and quality were both being materially improved as a result of several factors. One of the principal factors, of course, was gain in experience by the relatively inexperienced personnel with which the operation was started.

Although, as noted, we have obtained at Eau Claire no data which permit isolation of improvements due to chart control, such data have been reported by another ordnance plant. Experience in decrease of material with defective head-to-shoulder length at this plant is shown in Fig. 5, on a relative scale. Although the percentages are not large, the improvement is considerable in terms of total brass conserved.

The foregoing illustration is typical of nearly all control charts of this type. It must be emphasized, however, that each operation has its own particular characteristics and must be carefully studied in order to develop a detailed procedure suited to that particular operation. More briefly, it is necessary to tailor the chart to the particular job to which it is to be applied.

QUALITY CONTROL OF PRIMER PRODUCTION

It is interesting to notice a radically different type of chart which has also been of considerable use in our operation. In the manufacture of small-arms primers, it is customary to charge

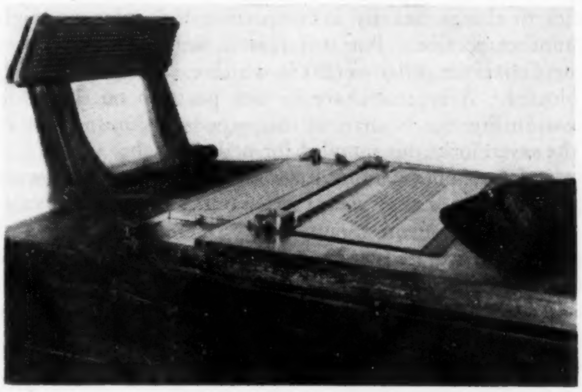

FIG. 6 PRIMER-CHARGING EQUIPMENT

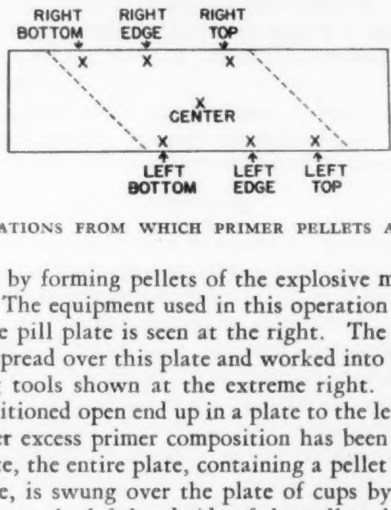

FIG. 7 LOCATIONS FROM WHICH PRIMER PELLETS ARE SAMPLED

each primer by forming pellets of the explosive mixtures in a pill plate. The equipment used in this operation is shown in Fig. 6. The pill plate is seen at the right. The primer composition is spread over this plate and worked into the holes by hand, using tools shown at the extreme right. The primer cups are positioned open end up in a plate to the left of the pill plate. After excess primer composition has been wiped from the pill plate, the entire plate, containing a pellet of explosive in each hole, is swung over the plate of cups by means of a hinged joint on the left-hand side of the pellet plate. At the extreme left of Fig. 6 may be seen knock-out pins, mounted in a plate which is carried on hinges. When this plate is swung down, the pellets are knocked from the pill plate into the primer cups.

The most important variable in this operation is the pellet weight. Primer sensitivity varies with pellet weight to such an extent that it is necessary to maintain this quantity within fairly narrow limits. Apart from the dimensions of the holes in the pill plate, the pellet weight is determined by physical properties of the primer composition, and by rather minute details of working the composition into the holes of the pill plate.

Customary inspection schedules call for weighing pellets

from the edges and center of the pill plate. The approximate locations used for this inspection are shown in Fig. 7.

An unusual feature of this operation is that small but consistent differences are usually noticed between the various positions in the plate. These may depend upon the individual characteristics of the operators carrying out the charging operation.

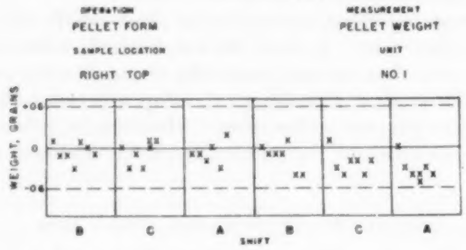

FIG. 8 CONTROL CHART FOR PRIMER-PELLET WEIGHT

Under these circumstances, it would be quite undesirable to plot averages. Such a procedure would fail to reveal tendencies to charge heavily in one portion of the plate and lightly in another portion. For this reason, we have established a control chart for pellet weight in which each individual weight is plotted. A typical chart for one position on the plate is shown in Fig. 8. A chart of this type is maintained for each of the seven locations sampled for pellet weight.

In order to obtain limit lines for the primer-pellet-weight charts, a variance analysis is carried out at regular intervals on results obtained from a number of different plates. In this analysis, we isolate variance estimates for items "between plates" and "between positions." The residual sum of squares is used to determine an error estimate from which the limit lines for charts are plotted.

An inspection system of the type described in this paper affords a tremendous amount of numerical data. An important part of the inspection procedure is summarizing these data in such form that supervision and management can take any necessary action. We have found it useful to report on a daily basis the percentage of points outside limit lines for each operation. Exceptional performance, either good or bad, is pointed out in this report. At appropriate intervals, a summary report is issued. It is probable that this type of reporting does not make use of all of the available information. More detailed studies will be necessary to determine whether this is the case.

CONCLUSION

In the foregoing discussion of Fig. 4, it was remarked that the limit lines shown in that figure corresponded to three sigma limits. Out of 80 points, 5 are shown outside the control limits for averages. This means, of course, that this operation is not in a state of statistical control. Unfortunately, this conclusion is applicable to substantially all of the operations to which quality control has been applied in our manufacturing process.

We clearly recognize that absence of statistical control is in principle undesirable, and in practice constitutes a situation requiring immediate action. Each chart which is out of control is a challenge for development work.

Without minimizing the desirability of attaining statistical control, we must further recognize that any of the elements in manufacturing can cause this lack of control. These elements may be broadly grouped as men, machines, and materials. Such development work as we have been able to carry on has shown in varying instances that any one of these elements not only can but does cause lack of control in the statistical sense. Failure to remedy this situation has not been due to lack of desire on our part. It has been caused by the lack of time at our disposal and by wartime conditions of manufacture. These conditions seriously limit our freedom of movement in respect to each of the elements of production.

It must be emphasized, however, that in spite of our failure to reach the happy state of statistical control we have derived real and concrete benefits from the institution of quality-control methods in the manufacture of small-arms ammunition. We feel that only a small proportion of the potential benefits has been realized, but that this proportion has been ample justification for the program which we have carried out. It is our hope that sufficient improvement in manufacturing processes can be made in the future to realize still more of the benefits offered by this system of control.

Diesel-Electric Locomotive Ratings

(*Continued from page 172*)

thermal-capacity rating. If the equipment temperature is 100 C and a heavy load of 160 per cent of continuous rated current is put on, the thermal-capacity rating is directly equal to the number of minutes required for the peak temperature to reach 160 C, which is considered the limit. If, as usual, the conditions are different, Fig. 3 may be used for approximate proration.

(*a*) If the current is not 160 per cent of the continuous rating, the curves give a new thermal capacity, corresponding to the particular current involved.

(*b*) If the initial temperature is not 100 C, and the final peak temperature not 160 C, it is usually sufficient for practical purposes to assume that the thermal-capacity rating, in seconds per degree, will apply to any practical temperature range.

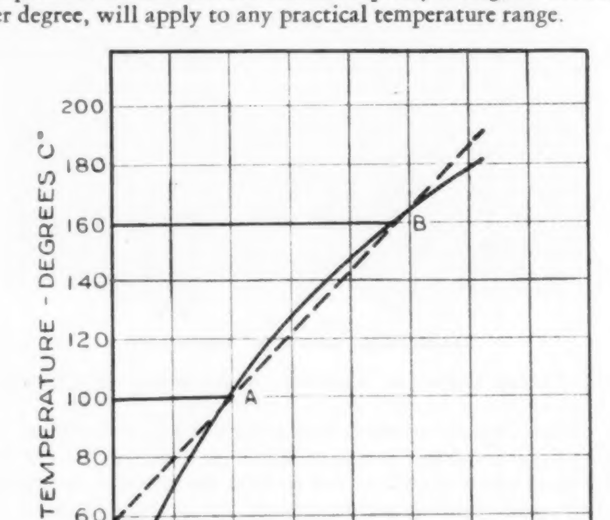

FIG. 4 TRACTION-MOTOR TYPICAL HEATING CURVE

Fig. 4 shows a typical heating curve of temperature against time, on which *AB* shows the range covered by the thermal-capacity rating. If the initial temperature is above 100 C, and we assume the same constant rate of heating, we will get a conservative result, since the calculated peak temperature will be higher than the true one.

On the other hand, if the motor starts cold, the serious peaks are generally due to very high currents, and the greater the currents the more nearly constant is the rate of heating, so that the method, although not exact, has considerable practical value.

To make a proper application, the temperature rise of equipment at reduced loads should be known, so that it can be estimated from what temperatures the rises due to peak loads will start. Such information can usually be estimated by motor and generator designers without much difficulty.

SCIENTIFIC METHODS *of* DISTRIBUTION

Engineering Technique as Applied to the Marketing of the Products of Twelve Industrial Companies

By FENTON B. TURCK and WILLIAM E. HILL

TURCK, HILL & COMPANY, INC., NEW YORK, N. Y. MEMBERS A.S.M.E.

OBJECTIVES OF THIS STUDY

DISTRIBUTION has been the neglected child of science. In their heart of hearts, many of the learned masters of research and production techniques nourish a snobbish disdain for the extroverts who sell the goods that production genius has created in such abundance.

Such an attitude is unwarranted and suicidal, because the object of all production *is* distribution.

The fact that distribution costs have risen steadily, during the very time that production costs have been steadily dropping, proves that distribution needs more of the engineering point of view.

For instance, in 1921 the direct factory cost of a chair was \$4.54; in 1941, \$3.07 in spite of a substantial rise in hourly wage rates. The consumer paid approximately \$15 for this chair in 1921 and from \$14 to \$15 in 1941. Obviously, it is futile for the scientific production man to save at the spigot, if rule-of-thumb distribution methods are going to waste at the bung.

Distribution now requires the well-known "59 cents of the consumer's dollar." The reduction of that proportion is the greatest challenge to the engineering mind.

The authors have noted the contrasts, as have all engineers who pass from production to distribution problems, between the scientific controls of processes of production and the rule-of-thumb which is present in almost every step in the chain of distribution.

Reduced to its essence, this contrast is one of accurate tools for measurement on the one hand, and a lack of appreciation for the necessity of such accurate measurements on the other hand.

The engineer, when he wants to know the temperature of a furnace, uses a pyrometer as a matter of course. With a \$250 instrument, he can be more than 99 per cent accurate in measuring furnace temperature. Without such an instrument, even the most experienced craftsman cannot be sure of judging within 200 degrees! Guessing, asking opinions, depending upon "experience" for the control of any production process which can be measured by accurate instruments, is so obsolete as to be ridiculous.

If all of the factors which influence the flow of manufactured products from factory to final user could be appraised as precisely as the production man measures his materials and controls manufacturing operations, the means for efficient, lower-cost distribution would be at hand.

With this basic problem of distribution control in mind, the authors set themselves the task of studying the work of those men in the field of distribution who have succeeded in making some phases of distribution more effective.

"Instruments" for the measurement of the factors which influence distribution do exist, as will be demonstrated in this study.

The authors gratefully acknowledge the collaboration of John E. Wiley in the editing of this article.

In the application of measurement tools to increase the effectiveness of distribution, difficulties arise because of three important factors.

1 The entrenched strength of empiricism among the policy makers and personnel of the distributive channels.

2 The presence of what might be described as "hunch thinking" in the distribution process is so well recognized as to need no elaboration.

3 The difficulty of recognizing the real value of a measuring device for controlling the functions of distribution. For instance: Most of the methods described on the following pages will be familiar to the reader. It is the thoroughness with which these methods are applied which makes them effective "measurement tools."

This paper is presented, not as a catalog of all known scientific methods of distribution control, but rather as a demonstration that engineering methods for applying to distribution the engineers' insistence upon measurement and control do exist.

Here a company has been forced to predict the demand for service facilities years ahead of actual needs. There a company has worked out a highly scientific method of determining its price structure. In practically every problem which arises in the entire field of distribution, methods for improving the economy of distribution processes are awaiting the inquiring mind.

If these methods were as easy to pick up and put to use as a pyrometer is, for instance, they would long ago have found universal application.

We submit that the examples given on the following pages, those referred to in the bibliographical references,[1] and examples which others can readily discover should be regarded as proof that accurate control is possible in this great area of industrial haphazardry.

Engineering control is not only possible; it is imperative if we are to succeed in developing the full potential of the engineering-corporate team on which business progress depends. The next great test awaiting business is its ability to bring its scientific knowledge of distribution up to the level of its scientific knowledge of production. That test confronts the management of every corporation today. The result is of vital concern to the producer, the distributor, and the vast consuming public.

We earnestly hope that others will agree with us to the end that there may soon be an acceleration of the application of science to every phase of distribution, with the end in view of raising still further the living standard of Americans.

EXAMPLES USED

Twelve scientific distribution principles are highlighted in the pages that follow. Each principle is exemplified by actual application in a leading industrial company. While company

[1] An extensive bibliography, part of the original paper, has been omitted to save space.—EDITOR.

names have been omitted, for obvious reasons, it should be remembered that each of the twelve reports covers the *actual* experience of a well-known company. Also, no cases are included which have not developed far beyond the theoretical stage. All of the methods described have paid off in lowered distribution costs.

In the case of eleven out of the twelve, the principles described have been in use for more than 15 years.

The method of selection was to choose for study and research only those companies which had pioneered an engineered distribution technique and had been outstandingly successful in following through on the methods developed.

In each of the twelve cases, the method is an "all out" effort on the part of the entire organization. So deeply does the point of view described in each case permeate the company which uses it that it is an essential part of the *management* technique.

The reader should bear in mind that it is business principles which the cases are concerned with, rather than a detailed pattern of application. Obviously, methods must be modified to suit conditions, but those described here can be applied to *all* business, whether large or small.

1 CUSTOMER DEVELOPMENT

The mountainous wastes of soliciting business that can never prove profitable, of allowing established customers to slip away, of failing to develop each customer to a natural potential, constitute a steady drain upon our entire distribution system.

To most businessmen, "selecting the customer" merely means that the sales manager keeps in general touch with the trade, through his salesmen and his distributors. In the case of this company, an intimate knowledge of every customer, *derived from engineering data*, has been the basic source of corporate policy decisions for more than 40 years.

Customer information, as used from the early days of this great organization, is as different from the vague "customer awareness" of ordinary sales management as a micrometer is different from a foot rule.

Years of use have so embedded the importance of customer knowledge into the organization that most of its personnel now comply with the principle without realizing its significance. Men who have grown up in the business are seldom aware of how much their methods differ from general practice.

This is significant, because in this and every other instance we shall cite, it is only the complete use of distribution control that is effective.

A chaotic price condition for all their products forced the management of this corporation over forty years ago to choose between "price" or "quality" as a business policy. The management chose quality.

This choice was predicated upon the ability of the company to use reductions in operating expenses of its customers as a means of taking the emphasis off immediate cost.

Operating economies, for customers, through correct selection and adaptation of the company's products were the basis for developing a quality market.

With growing acceptance of this basic idea by customers a unique and highly profitable business was developed.

It is to this particular turn in events in the history of this company that the science of distribution owes one of its simplest, yet most significant, advancements—the technique of developing customers.

The importance of a complete "knowledge of customers" is demonstrated by the fact that 60 per cent of the man-hours of the *sales organization* is spent in obtaining knowledge of the company's customers and prospects. The files maintained on accounts contain from 40 to 500 pages of detailed information per customer. An average of fourteen months is required to gather essential information before the company feels it has a true understanding of the customer and his needs.

Procedure of obtaining knowledge of customers:

1 Every prospect is analyzed *before* he is solicited. Neither direct nor indirect sales activities are allowed to start until a detailed survey is made to determine the annual consumption by the prospect of the several types of products manufactured by the corporation. If no chance for mutual profit is indicated, the prospect is not solicited.

2 Where possible, information is obtained in the plant of the prospect as to competitive sources used for the current supply of each type of product.

3 At the home office a thorough analysis is made of the organization setup of the prospect, with the addition of such corporate information as is necessary to have a full working knowledge of its business, policies, direct and indirect affiliations with competition, in addition to the usual analysis of banking and trade affiliations.

4 With this background information a suitable procedure for the sales force is developed.

5 Upon receipt of the first order, a record of dollar and quantity volume of sales of company's varied products is set up. Such a record is maintained for each of many thousands of customers.

6 Dollar and quantity volume of customers' purchases from competition are also included in the customers' record, where obtainable.

7 Thus, cumulative figures on purchases by the customer from the company and from competition are on record, and these figures are carefully analyzed to show business received and business lost to each competitor.

8 The relation of business received to that of each competitor is used to determine frequency of salesmen's calls, the need for special service, and the strategy of following up each customer.

9 Checks on the relative efficiency of the salesmen in each territory are obtained by compiling and composing customer data already described.

The company's operating profits have been maintained at a high level since the adoption of customer development as its major tenet in distribution procedure. This is a direct result of the fact that the company obtains an average of 37 per cent of its customers' business, as contrasted to the 10.4 per cent which an authoritative investigation showed to be high among competition.

The seemingly extravagant allocation of organization time to digging out customer knowledge and the office time required for interpreting and directing the use of this knowledge have been justified by the most efficient distribution in the field.

A carefully selected group of 697 industrial users of products in the company's field were asked to name the company which they preferred on the basis of reputation, quality of product, service rendered, and excellence of sales personnel. On all counts, the subject company received a preference ranging from 200 to 400 per cent over its competition.

The advance spending for facts hammered down the final cost of distribution.

The methods used are simple. They are readily available to any other company, either small or large.

2 CORPORATE ACCOUNTS

In the minds of most people, selling means a sale made by an individual to an individual.

This concept of the sales relationship is unfortunate, if it results in neglect of the economies and stability that are inherent in the corporate account.

The characteristics of a corporation may be marshaled into a corporate-account phase of selling which results in stable, profitable distribution arrangements of very great value.

The *personality* of a corporation does exist. We know it by such words as good will, corporate policy, organization.

Every corporation has a number of steady repeat customers. These old reliables are the result of the fact that the management of one company knows and respects the other and con-

sciously or unconsciously gives first consideration to the goods or services of these permanent customers. In a number of instances detailed costs have been developed which have directly shown the desirability of such established corporate accounts.

A review of the history of corporate accounts with many companies, however, indicates the purely accidental and chance development of this type of business.

A study of twenty companies with a preponderance of corporate accounts contrasts vividly with twenty other corporations whose sole interest has been dollar-volume business, without regard to source and continuity. The dollar-volume group suffered unmercifully with each slight recession in trade conditions, while the companies stressing corporate accounts maintained a steady growth.

In the case of one company the selling cost per dollar of sales for corporate customers is one tenth of the over-all selling cost of "here today, gone tomorrow" business of the same company. The relative stability of the corporate accounts is a great asset.

The management of this corporation in 1928 became thoroughly convinced of the advantages of corporate accounts and made plans to build up this type of business.

In three years, through a concentrated effort by the management, sixty per cent of the company's annual sales volume was on a corporate-account basis. One account, which yielded $26,000 per year when the plan was started, grew into a corporate account representing a consistent business of $300,000 per year. Many other accounts showed similar relative progress.

The principal tools used by this corporation to establish its corporate accounts were:

1 A wholehearted decision to concentrate on the cultivation of corporate accounts. This policy sustained the necessary investment in talent and effort required of management and operating forces.

2 A six-months' review of all important sources of business with the objective of selecting the most desirable repeat customers.

3 A careful analysis of each account to determine the obstacles that had to be met in order to convert the customer or prospect into a corporate account.

4 The matching of these obstacles with what the corporation could offer on an organized basis, such as engineering assistance; mutual exchange of business; design or adaptation of product to meet specific requirements; co-operative promotion of product; warehousing; delivery or service innovations giving new competitive advantages to the customer; financial or credit assistance.

5 Complete selling coverage by management and operating personnel in order to assure a thorough knowledge of the product and service requirements of the account.

6 Where the long-term advantages appeared to justify the effort and expense, treating each account as an individual distribution objective.

7 Adjustment of the sales organization so that particular individuals serviced the account in any part of the country regardless of sales territories.

8 All departments of the corporation co-operating in the establishment and maintenance of each corporate account.

Undoubtedly, most companies appreciate the *value* of corporate accounts. However, few corporations have undertaken a deliberate organized effort to build up this type of permanent business.

Stabilized sources of business can be developed through engineering procedure. The result is repeat customers with economy and lowered costs of distribution.

3 STABILIZING DEMAND FOR CAPITAL GOODS

The year 1932 was fearsome for manufacturers of major equipment; 1933, in most cases, was little better, if not worse. Surprisingly, one manufacturer of plant equipment reported here made a profit in 1933, a year of extremely low industrial production. Furthermore, throughout the depression, this company paid at least a partial dividend every single year.

YEARS IN WHICH FOUR MANUFACTURERS OF MAJOR EQUIPMENT SHOWED A NET LOSS, 1932-1935

Year	This company	Company B	Company C	Company D
1932	Loss	Loss	Loss	Loss
1933	..	Loss	Loss	Loss
1934	..	Loss	Loss	Loss
1935	..	Loss	..	Loss

Orders in this industry in 1932 were practically nonexistent and the major competitor of this company is only now clearing up arrears on its preferred stock. There also was the machine-tool company that was reduced in that year to a single order in its shop—just *one* order. How then were so many orders obtained by this manufacturer in such a period of dearth?

Its plans had been laid well in advance of the 1929 break—perhaps 25 years before that time. Purchased in 1894 in bad financial condition, the company had the blessing of new management, around 1900, that recognized the importance of stabilizing, as far as possible, the demand for its capital goods. There was no economic misconception of the susceptibility of this industry to general business conditions and the relative inelasticity of demand for their products. Rather, this management was realistically aware of the "feast or famine" characteristics of its business—to the extent that it did something about them.

For years it had built the business, customer by customer, corporate account by corporate account, to establish a primary relationship with the small number of well-financed and diversified accounts in its highly concentrated market. It staffed the organization with the most capable men in its field and pursued a rigorous policy of management control to present the most effective engineering-trained negotiators to handle the multiple purchasing influences in its direct sales with its customers. Furthermore, it diversified its lines with companion products.

On this rock base, the company systematically sold its major accounts a new habit of buying their major plant equipment. Each customer was sold on budgeting its specific requirements at least a year ahead, instead of spot buying. In certain cases, customers were sold on programming purchases as much as five years ahead. This crystallization in the customer's mind of the necessity of planning and budgeting ahead its equipment purchases has the effect of setting up business in good times that will not totally disappear in bad. To facilitate this procedure, the company's sales engineers do the following:

1 Study the customer's manufacturing, engineering, and purchasing departments, according to an organized selling plan. They familiarize themselves completely with the personnel and with the equipment needs and the operations of the account.

2 Create an understanding of obsolescence in equipment by showing customers how installation of new equipment would create savings in production costs.

3 Build executive support in the account for advance budgeting of equipment through a departmentalized top-management coverage procedure.

In 1932 and again in 1938, this policy paid off. Instead of abandoning all equipment purchases, its loyal, well-diversified and well-financed customers continued to place some orders, however small, as a result of their advance-budgeted programs.

At the peak of war output in 1944, with industrial production at an all-time high, the company is busy helping its customers plan ahead their postwar equipment-purchase programs. The only limitation to this all-out and scientific procedure of stabi-

lizing demand for capital goods is the scarcity of engineers experienced in distribution.

Planned budgeting of customers' future requirements will help to stabilize the "feast or famine" characteristics of the capital-goods business.

4 MARKETING BUDGETS

Accurate forecasting of the volume of business that may be anticipated is essential to the sound and economic operation of a company. This essential in applying engineering management to distribution can decrease production costs, improve marketing programs, stabilize employment, and increase profits.

With such vital elements at stake, the ordinary method of operation is to send out inquiries to the district heads of sales for their estimates, on a monthly or quarterly basis. Naturally such estimates are heavily colored by any salesman's wishful thinking. Usually, the district estimates are developed by inquiries to the trade. The home office then assembles this "considered judgment" from the field and adjusts to past results with the assistance of an economist or statistician. The sales budget is then built round these estimates and is presented at the general sales meeting.

As a result of this method, unforeseen circumstances often develop which undermine the confidence of the management in the accuracy of the sales budget. If it has been too optimistic, plants are shut down to await developments. If the budgets have been too conservative, there is a scramble to increase production, with dangerous increases in inventory.

Whatever the procedure, the fact is apparent that the sales budget, as developed by usual methods in distribution, is opinion and, as such, does not offer a sound basis of confidence for steering a corporate course. Lack of true knowledge of the type and volume of business that can be anticipated represents a major failure in distribution methods.

In contrast to the above, the example of a well-known corporation should be followed by others. This company budgets its full year's operations on exact quantitative analysis, based upon completely factual and independent information, adjusted periodically to changing rate of sales, inventory, and other pertinent influences.

It was in 1921 when this company led its industry as the first to measure the market on a national scale. Monthly sales figures by manufacturers' types were gathered in 31 states. These became the basis of the most minute checks on performance of every outlet in every county. Standard accounting systems became compulsory in every outlet at the same time. This enabled sales managers to set up bogies in every department of the business—new products, used products, parts, and service—and gave direction to all corporate distribution, production, financing, and design efforts.

One outlet, as an example, estimated by rule of thumb it could sell 350 units for the coming year in a certain territory. The budget, laid down by the company's analytical methods, called for 500. It also included the type and size of units and the nature of the customers. Operations were geared to this basis; the outlet stepped up its merchandizing to this level; and approximately 500 units were sold. It works both ways.

The effect of this procedure has been profound. Distribution, so analyzed, dispels much of the darkness of the future.

An elaborate factual technique has been perfected to determine the number of all the products of the company the market will absorb. The market potential is first determined for each county and populous neighborhood in the United States. The potential for each community is not proportional to the population of each, rather each local potential is constantly raised or lowered with local conditions, viz., when a highway is diverted, an oil well dries up, or other factors change.

Shortly after engineering sales budgeting was started, the production department began to set production schedules on the basis of advance sales estimates—one month firm and two months tentative, as is the practice today. This was a complete reversal of procedure from the conventional practice of manufacturing first and then marketing the number produced.

The national sales potential of one division, as an example, was 40 per cent of its price class, 800,000 units a year, from 1936 to 1939. This basic potential is the governing factor in the number of franchises granted by the management for the distribution of its products; it also governs the location of each outlet and the rent it ought to pay; and no outlet can be added or replaced unless the potential statistically permits. The potential is designed to enable the 9000 dealers to make 15 per cent on their capital over the business cycle.

To compensate for deviations from this base potential, a sales expectancy is minutely maintained to control weekly production of units by volume and by type. This may be more, or less, than the potential, depending on business conditions.

Each outlet reports its sales and inventory three times a month. Arriving at the regional office, these reports are summarized and wired to the head office. Every ten days the management knows how many units were sold the period before and how many are in stock. Knowing the current rate of sales and the normal seasonal movement, future sales are forecast for the remainder of the year. This forecast governs weekly shop production, orders to vendors, financing and marketing procedure.

As the entire industry is well reported statistically, monthly sales of each product of each manufacturer in the industry are used to supplement the company's ten-day reports. Hollerith card analyses classify these data by every conceivable factor, from occupation and location of purchaser to amount of cash paid on each sale. These statistical facts provide a record and a forecast for all current and future operations.

The result is that this company builds a major segment of the industry. In the tough period 1929–1936, it was "in the black" every year. Three competitors were "in the red" in seven of the eight years; one lost money in five years; while two others similarly suffered in four of the eight years.

The savings in costs, by reducing error to a minimum, are tremendous, and have had significant influence on the social development of the country. Finally, the stability of employment, as a result of explicit anticipation of demand, is a record of extreme desirability—a reflection of the future of engineering management in bridging the gap between the well-being of the individual employee and the industrial plant of the nation.

Engineering accuracy, when applied to the sales budget, results in greater confidence to plan ahead, as well as operating economies and reduced cost of distribution.

5 DISTRIBUTION PLANNING

Looking twenty years ahead to distribution requirements of 1964 seems futile, yet several of our greatest corporations owe their current leadership to the fact that, as small, struggling companies in the early part of the century, they did look ahead. They literally "engineered the future."

The companies which have established the best record of forecasting distribution requirements, however, are those which required heavy and continuous investment in facilities for the services rendered. Transportation costs continually emphasize the fact that in distribution the facilities must be where the customers are.

That the future location of customers can be predicted within safe engineering limits is illustrated by an outstanding company. This company has for forty years directed much of its management's talent toward creating an engineering basis for measuring future trends of their markets and consumers. These predictions are constantly adjusted to changing markets and consumers, in order to keep data five to twenty years ahead of current status.

The clear-cut problems of the company led to the development of a long-term analysis for the purpose of establishing distri-

bution points which would anticipate the center of gravity of each market by twenty years.

For nearly forty years, under circumstances of increasing cost of labor and materials, the ratio of cost of distribution facilities to total sales has held within limits established in 1906. This ratio has been maintained in spite of vast and costly improvements in the quality of their product and services.

To maintain its "trend studies," the company has employed 300 engineers and a proportional field staff. Two principal surveys are prepared by these engineers:

1 A general nation-wide study—a master yardstick, which is developed by assembling a vast amount of past and current information on the following items:

- (*a*) Migration trends of all population types from one section of the country to another
- (*b*) Power facilities
- (*c*) Transportation facilities and costs
- (*d*) Commercial transactions by geographical centers
- (*e*) Manufacturing facilities and activity by types and classes
- (*f*) Agricultural production
- (*g*) Wage rates in various geographical centers
- (*h*) Retail trade in each section.

These items and many other collateral studies are the basis of developing a "trend line" for the country as a whole and for various large districts. This over-all picture is first set up and then checked and rechecked. Data are never allowed to become a pile of dead statistics, but rather are used as a shadow of the past to project a living image of the future.

2 Local district surveys represent the working details in the trends established by the over-all surveys. Each local survey establishes distribution points and local product needs. Residential customers, as well as six classes of industrial customers (offices, retail stores, wholesalers, manufacturers, institutions, and hotels), are covered.

The field staff develops an accurate picture of the potential market by securing data on the occupancy of every building.

Some districts require special attention. Buffalo, for example, where a re-survey was made in 1929, was again completely reviewed in 1932.

Product improvements can be accurately evaluated through these surveys even though they are primarily intended as a forecast of distribution needs. In one spectacular instance a new type of facility was uncovered and installations began immediately. Without the surveys, years would have passed before this product need would have become apparent. In addition, a saving in costs of $85,000,000 is indicated as a probable result of the surveys.

The nation-wide survey of this company, together with the local measurements of its customers, have become the "bible" on distribution to this progressive organization. Forty years of weighing results of their engineered distribution have proved that management can look ahead and thereby improve the service to its customers and save vast sums of distribution costs.

In this case, "looking ahead" is accomplished by three hundred engineers. But the same principle can be followed by a single engineer. When such policies are followed in a majority of companies they will represent for industry a vast progressive step away from guessing and crystal gazing.

Where large investments in distribution service facilities are necessary, engineering of service-demand trends can repay its costs many times over.

6 PRICING POLICY

For many years, the pricing policy of American industry has been alternately confused by the many technicalities of bookkeeping and oversimplified by the naive policy of charging what the traffic will bear.

As accounting systems grow in complication, the means of setting prices grow more and more involved. Sales managements, experts, statisticians, and economists knit their brow- over the question of what to charge the consumer.

In the case of one of America's most successful corporations, however, pricing has not been a matter of a bookkeeping routine, of guessing, nor of competitive pressure. Instead, it has been a clear-cut policy, based upon carefully worked-out scientific methods of determining exactly what prices should be in order to develop the widest possible markets.

Through this application of an original concept of pricing during the past seventeen years, the customers of the company, which include most of the population of the United States, have benefited from an average price reduction on all products of some 33 per cent.

In 1926, there was a showdown within the organization which resulted in the present pricing policy of the company. Up to this time, the management had been divided into two camps: Those who believed in holding prices as high as possible and making the most out of each new product developed, and those who believed that there was an inevitable relationship between economic development, production, costs, and prices.

The latter group were convinced that if prices could be reduced through improvement in manufacturing technique, new markets would open up. This group prevailed, and it was decided that even in the case of products which involved a monopoly, prices would always be kept at a level to include only a reasonable mark-up from production costs.

The victory of the second group is the basic reason why this organization was the pioneer in modern pricing and has become an outstanding example in America of enlightened, constructive management.

Two examples illustrate their long-term pricing policy and are clear indications that the company did not wait for its customers, the public, or its competitors to force price policies upon it.

1 A certain new product, introduced in 1933, had been voluntarily reduced in price 27 times up to the outbreak of the war.

2 In planning the marketing of another new product of potentially wide acceptance, this company projected the probable sales results over a ten-year period. In projecting these plans, the company included probable price reductions and based estimates for equipment and plants upon the widened markets which these lowered prices would produce.

It is significant that all price policies are the *joint decisions* of the sales, production, and research departments of this company. As a result of co-operation in pricing, these three forces have grown into an inseparable combination in all corporate activities. Each division of the company has a general manager and under him is a director of sales and a director of manufacturing. The management considers it essential that these two personalities be co-operative, and adjustments are made until a harmonious combination is secured.

A traditional practice in the distribution procedure of the company is to discontinue high-pressure marketing of products that have finally become staple items, since gross profits become negligible. Staple goods must, of course, be at the mercy of the market.

In addition to a consistent price reduction, the operating profits of the business have climbed from 13 to 31 per cent, since the policies outlined were adopted. This achievement has improved its position over competitors. In 1934, operating profits were 2.6 per cent over the average of this company's direct competitors. Six years later, this margin had advanced to 11.1 per cent. For the entire period, operating profits have been above those of leading competition by an average of 6.3 per cent.

This company's record is living evidence of the fact that

scientific pricing can be a tremendous factor in engineered distribution.

The application of engineering principles to pricing policy has the quadruple advantage of lowering prices, extending markets, reducing distribution costs, and increasing profits.

7 DISTRIBUTION ADMINISTRATION

Corporations, like nations, can go "all-out" for distribution. It is possible to co-ordinate a company's financial, research, engineering, purchasing, manufacturing, as well as its marketing departments, into one mighty distribution offensive.

Only a highly organized system of liaison can accomplish this co-ordination in a large corporation, but it has been done, as shown by what follows. In a small company, the problem is not so difficult.

This company, through uncontrollable economic circumstances, was losing a vital market for a substantial part of its direct sales. By engineering its distribution this situation was reversed. In three years this company more than replaced lost volume by developing its distribution through jobbers. During this time jobber volume grew from 2 to 20 per cent of its total sales. This was completely new business to the company, representing many millions of dollars. Corporate mobilization of all essential departments achieved this result.

The significance of the rise of jobber sales from 2 to 20 per cent is clear, when it is noted that during the period that this rise was occurring jobber sales percentages for the entire industry were dropping.

It is interesting to trace the organized procedure of this company. First, the market-research division of the company studied the market which had supplied the major source of the company's direct sales. From this study it was clear that this market would not return to normal for many years (92 per cent of potential in its original field was wiped out during the early depression years). The possibility of a comeback of this industry in sufficient proportions to restore this lost source of business was hampered by the following adverse factors: Restriction of the long-term source of capital funds, drastic increase in production costs, and undermining of long-term confidence.

The technique employed by this company to expand its jobbing outlets was:

1 A complete analysis of all products of the company, with particular consideration of all classes of products currently distributed through all jobbers. This study was conducted in every section of the country and required more than two years of solid effort to complete. Every possible consumer of steel products, large and small, was investigated. Through the intensity and thoroughness of this analysis it was possible to locate tonnages of steel which had never before been charted.

2 A detailed market analysis of the possible channels of distribution of each class of products.

3 A geographical classification of the actual and potential jobbers prepared to handle each product.

4 Proposed list of products for which jobbing outlets were to be sought and developed.

From this analysis it then became possible for the management to choose a definite list of jobbing outlets for each of the selected products. With this initial information, a complete study was made by engineers of all principal corporate divisions of the company to determine what steps would have to be taken by each division, in order to acquire and develop the selected jobbing accounts within a limited time.

The means of securing each jobbing account were specifically analyzed and appropriate action was determined upon before any direct moves were instituted. The selection and acquisition of each jobbing outlet represented the use of the *combined* management resources of the company.

Based on the analysis of the markets for its products, a large and a small jobber was secured in each major distribution territory, and a sales-volume quota was established. As an incentive, the principal jobber was given practically an exclusive arrangement and a particularly attractive discount. In territories representing smaller volume a nonexclusive policy was followed. As an example, in the New York City district the principal jobber handles 95 per cent of the company's business sold through this type of outlet. In some instances, the company provided strong direct-selling assistance, lending trained personnel to the jobber to improve his general merchandising procedures. Indirect temporary financial assistance was granted some outlets and in other cases the company undertook to pioneer the development of new markets for the jobber.

Market research, engineering classification of products and channels of distribution, the direct assistance of the purchasing organization, of the treasurer's department, and of negotiating personnel, and all the facilities of the sales department were applied in the accomplishment of this corporate objective. The exhaustive study which showed the direction of action required would not have produced the tangible results without the co-ordinated effort of each principal division of the company's management.

This feat of developing new methods of sale to bring in new business through new outlets was accomplished in three years. It is a permanent tribute to an "all-out" mobilization of corporate management for the betterment of distribution.

Many companies have decentralized management resources which could be marshaled, under a properly engineered plan, to secure maximum distribution efficiency.

8 DIVERSIFICATION

The fact that a company must have more than ample resources and the urge to expand is often overlooked. When expansion is undertaken on a hit or miss basis, distribution becomes costly and chaotic.

In 1928, a company having 92 per cent of its potential market in a major field began to study the question of expansion into new fields.

Before any direct action was taken by the company, a number of engineers were employed to investigate thoroughly seven different industries. These engineering studies represented thorough analyses of the existing markets of each industry, their history, current and projected volume, pricing trends and discounts, and distribution procedures of the principal companies in each industry. A complete pattern of the prevailing selling practices employed in each industry was developed.

In addition, current products were cataloged, raw materials studied, production costs analyzed, equipment and techniques involved in the manufacture of each product thoroughly appraised. The frequency of new-product designs, the time interval for public acceptance of new products within each industry, estimates of manpower required for definite schedules of production, and other pertinent factors were analyzed.

While the foregoing steps were being pursued for each of the seven industries selected, other engineers made a complete investigation of the company itself, to find out how its aptitudes and facilities would match the opportunities disclosed.

The final selection of the industry that offered the best field for expansion was determined by weighing and comparing scientifically accurate data. While this company was and is rich in executive ability, those executives realized that *judgment*, like *justice*, is blind until all pertinent facts are available. Sixteen years of proved results testify to the soundness of the decisions which ensued.

It is significant that the methods used so successfully in this first expansion have worked equally well in each new expansion program that has been undertaken by the company.

The aggregate earnings of the company in the fourteen years following this expansion in new fields have shown an increase of 38 per cent over an equal period before expansion.

A by-product of planned expansion was the setting of a definite objective for product-development work. Previous to this

orientation, the new-products department had scattered its efforts in all directions. Miscellaneous items from automobile horns to fire extinguishers were constantly popping up, with little or no thought as to how they would be distributed.

With a direct objective for developing products, eighteen new ideas have been adopted and pushed to a leading position in the new industry.

In contrast to this scientific method of expansion are the numerous examples of poorly planned "drives" into new fields which are common industrial occurrences.

Engineering methods are particularly important in diversification of a business, because impetuous ventures into new fields are often responsible either for company failures, or more frequently, for losses that pyramid distribution costs.

9 Product Development

Many a company attempts expansion through product development without first predetermining its manufacturing skills and then applying them to those product fields that represent a major opportunity. Lacking this, it hopes to obtain some unique product, patent, or specialty by chance circumstances.

The company covered in this example is noted for its new product development. This company has a cardinal principle of expanding only into established markets in which it can engineer a superior product, turning it out cheaper and in vaster quantities. This policy is based on the use of its basic fabricating process.

With a single unique processing method, developed during World War I, this company has applied manufacturing advantages to the development of one product after another until, today, it is the predominant factor in many markets.

Now, with a $1,500,000 laboratory, nearly self-sufficient in engineering, with 150 engineers on basic and product research, metallurgy and ceramics, and with 150 other engineers on operations, laying out and designing production lines, the company has a mammoth machine shop to make most of its own special-purpose equipment. This is the record of its expansion in applying its basic production technique to new markets:

1921 One particular machine, developed twenty-three years ago, still maintains the company as the lowest cost producer in the field, yielding 40 per cent of the available business, with customers feeling no temptation to build their own product.

1925 The same basic fabricating process was applied to products for another industry, which an analysis showed as holding a great opportunity. Starting with a single customer, by the end of the year twenty-three additional customers had been added, and this newcomer found itself with 90 per cent of all the business for this product in the United States.

1927 The company erected a new plant with a huge capacity to manufacture a product which it had spent three years developing for another large industry. The product was not only larger, more uniform, and cheaper than that previously used, but by its method of manufacture (basically the same as that first applied in 1921) wall thickness could be cut down without losing strength, thus effecting still greater economies in the use of the raw material. The analysis of the potential in this particular market was completely accurate, with the demand for the product reaching a tremendous peak in the late twenties and early thirties. 90,000 tons of raw material a month were being consumed by the company in 1929 and shipments were at the rate of several thousand carloads a month.

1933 Thoroughly analyzing a field dominated by competitive materials fabricated by other processes, the company, in recognizing the potential in this market, designed a new, less costly, and superior product, again using its basic process.

1935 Having effectively studied the opportunity for a companion product to supplement that developed in 1927, the company introduced one by simplifying the manufacturing process and producing a more economic end result. Since that time, it has acquired two established companies to further round out its position in this field.

1937 The company undertook the development of additional products for its consumer-goods markets in which its basic processing advantage would apply. As a result of the success of the application of its production technique in the consumer-goods field, the next depression will not catch the company undiversified.

Product development can be costly or even ruinous if the manufacturing skills which characterize a particular company are not first identified and then directed, by an organized procedure, to the markets which present the greatest opportunity for those skills.

10 Market Development

Every businessman is familiar with the "sour grape" markets of industry. These are the "obvious" markets that nearly every company has tried to enter, but failed.

The costly procedure of attacking markets just because they "look attractive" should be corrected.

To any management interested in a more scientific approach to its "obvious" markets, the following example should serve as a helpful guide.

While it may appear academic to the casual observer, an investigation of the causes of failure to "crack" obvious markets should start with four obvious questions:

1 Does the market *actually* have the potential it appears to represent, or is it a new-business mirage not worth major attention?

2 What are the essential characteristics and requirements of the market?

3 What can the company do to meet these requirements?

4 Can the company make a real *contribution* to the mutual advantage of all concerned?

Not many years ago a certain company undertook the development of an "obvious" market which it had been unable to "crack" previously. Four major attempts and an annual assortment of sporadic attacks in twenty-two years had cost many hundreds of thousands of dollars of direct expense alone. Yet the challenge always remained—a huge industry representing an enormous potential source of business.

With this background the decision was made to "lay the ghost" once and for all by a thorough investigation of the actual market potential, the essential characteristics of the business, and the contribution to be made for mutual advantage. A long-range program of investigation and commercial research was undertaken.

Field interviews, conducted by engineers, disclosed the scope and attractiveness of the market and the portion available to the company. The previous year, the total sales of the eight most important prospects were in excess of $2,600,000,000 and the total of thirty-one companies in the industry was $3,146,000,000. The purchase of the particular product in question, by these companies, was a microscopic 3/100 of 1 per cent of their sales. In similar industries, this ratio, confirmed over years of application, varied from 2 to 6 per cent. From this disclosure it was apparent that the industry in question was not convinced of the economies to their business of the use of the product.

A goal was established on completion of this market survey. The business to be obtained from ninety companies in the industry was budgeted from the findings established by the work of four technicians, engineers experienced with the industry, and eleven field workers.

Year	90 Sources
First	$ 550,000
Second	800,000
Third	1,500,000
Fourth	3,000,000
Fifth	5,000,000

Costs were budgeted against these estimates and the company now had a clear perspective, for the first time, of the job to be done and what was required from each division of the company to execute the program.

After this crystallization of a realistic goal, the management then launched the major stage of the research program.

It was found that most companies in the industry comprised three completely different types of business rolled into one. The research clearly showed that this grouping of totally different types of business within one corporate structure had been a confusing factor in past marketing procedure. Also the fact that the lines of management in most companies of this industry followed the over-all corporate structure rather than the functional units of the business had served to make it "impossible to see the trees for the forest."

Based on these simple disclosures and supported by a reclassification, it was possible to demonstrate the advantages of the company's product to *each* separate unit of the business, making three sources of potential business with each prospect. As a result of segregating the interests and mutual needs of each segment of its giant prospects, the company has been able to prove a mutual advantage. The company is at least realizing the goal it has coveted for so many years.

Much wasted sales expense can be saved, and directed into constructive market development, by an engineering investigation of the actual requirements of a given market.

11 ORGANIZATION

Distribution procedure, of a truly scientific nature, requires a sales organization that is conditioned to meet exacting requirements.

Frequent discouragement in immediate results by management employing supposedly advanced procedures has often resulted in the abandonment of a potentially successful sales organization program. All efforts must be directed to the conditioning of the individual man to complete each actual sale. Therein lies the success of systematic sales organization, as the point of sale is the spot to ring the corporate cash register.

This example deals with a world-famous company the new management of which in 1914 began a policy of basing its entire sales program on systematic preparation of its sales personnel to prevent failure of *any* salesman at the point of sale. The degree of concern on this one point is so intense, that the head office is immediately advised of each lost order. Swinging into action, the management completely reviews the situation, not only with the salesman but with his branch manager and with his district manager, to determine the cause and to prevent recurrence.

In 1927, a long-range plan was organized. One hundred and forty college graduates were brought in as prospective salesmen. Thereafter, until the war, the normal salesmen's class was fifty meticulously selected college men.

Intrinsically, the sales force is different from others in these vital factors:

1 Complete engineering analysis to predetermine all possible conditions a salesman may be required to face to complete a sale.

2 The rigorous standards imposed upon average-type applicants, to make sure they are right material for this company. Managers of the company conduct a nation-wide combing of each year's crop of college graduates. Selection is based on average scholastic ability, accounting, and business training, campus managerial record, and sales personality.

3 The consistent indoctrination of the individual in the methods required to make a sale under all conditions.

4 The complete discipline of a salesman's working hours and sales efforts and supervision of his results. This is supplemented by periodic evening educational sessions.

5 Recognition and reward of the individual through internal sales force competition, with constant stimulation through contests and comparisons.

6 The salesman is made to feel that sales records and reports are for his assistance as well as for the company's.

7 The average age of the 600 to 700 salesmen is 32. The youthful vitality in this sales force, ever pointed to completing *each sale*, is maintained by periodic classification of each salesman on a basis of results. If a man in the "third third" cannot improve, after adjustment of position, location, and further education, there is no incentive for him to continue with the company.

While the individual is regularly impressed with his potential leadership (with the nonexistence of organization charts "everyone is on the sale level"), he is systematically indoctrinated to live and breathe his company so that he will be capable of closing each sale.

The rewards to the company of the use of scientific methods of sales organization are apparent in its growth to a $20 million wonder of prewar management. Even those salesmen, who are forced into other work, usually regard their period of conditioning with this company as one of their greatest assets.

Maximum sales results can be obtained at least cost by systematically conditioning a sales organization in the predetermined methods required to complete each sale.

12 FOREIGN DISTRIBUTION

The distribution of goods in foreign markets will respond to engineering techniques as readily as domestic sales.

However, the record of American industry in fields outside the United States is not inspiring. Many a balance sheet has seen large expenditures repeatedly charged off because of changes in foreign governments, waves of nationalistic legislation, and fluctuations in exchange.

The traditionally successful Dutch and English foreign-trade procedures are classic. Yet when an American company contemplates the opening of foreign markets, a second-hand copy of the Dutch or English procedure is inadequate. Equally insufficient is a replica of the company's procedure in the United States.

One American company, which systematically developed its foreign markets over a period of forty-five years, had half its total sales in foreign markets by 1928. As an indication of this company's success, average annual dividends, to 1940, were two million dollars.

The stability and success of this enterprise can be traced to the consistent policy adhered to by the management in establishing native management in each country with full authority to manage the operations of the company.

The question of foreign sales was first raised in 1894, when the United States business was almost at a standstill. Several unsuccessful trials in Switzerland and Germany, where similar products were nonexistent, convinced the management that haphazard selling in foreign markets had its disadvantages. Spurred by this experience of the ineffectiveness of distributing European products from Buffalo or Detroit, an English warehouse branch was established in 1895 with an original investment of $55,000, which stake was repaid in eight months. From this base of operations the organization of the fundamental distribution for all subsequent foreign markets was laid out. The resultant foreign investment on the books of the company was $25,000,000 in 1939, yielding sales in excess of $22,000,000.

The basic elements of this policy are summarized as follows:

1 Recognition that manufacture of the products should eventually take place in the consuming country.

2 Management must be native to the country with complete authority as soon as suitable personnel can be trained to administer the business.

3 Adaptation of the design of the product to the consumer demand of the country.

4 Establishment of a strictly graft-free procedure throughout the operations of the country.

5 Creation of one trading center to sell in countries in which manufacturing facilities are not justified; purchasing products from subsidiaries in other countries offering lowest cost.

6 Strict maintenance of the independence of each national unit, limiting American supervision to two over-all advisers, with several traveling auditors.

7 Allowing local capital participation where the national laws so decreed or good-will factors made it advisable.

The organized procedure for opening a market in a new country was equally as strict in observance of the importance of *native* conditions and preferences.

Investigation of the market potential was first made to determine the justification for entering the country. This was usually performed by specialists in foreign trade.

Distribution was started through established channels, preferably native born. When the volume of business justified, a branch, staffed by native-born company representatives, would be established.

Finally came the establishment of a plant; the training of complete native management; and the withdrawal of American personnel.

Foreign subsidiaries were gradually set up with a plant in each of these countries: 1898, France; 1901, Germany; 1904, England; 1909, Italy; 1911, Austria and Belgium; 1929, Spain; and 1929, Switzerland.

Sales offices were also established in Holland in 1929 and in Sweden in 1930. After World War I a second plant was established in Germany and Italy, with a half dozen more in France. The economic conditions of each country determined the type of expansion of facilities.

The consistency of a systematic policy and procedure in regard to native administration for foreign markets had helped the company surmount political upheavals, exchange problems, economic depressions, and even war. Those in occupied or enemy countries in 1939 and 1940 were left in the hands of their competent native top managers—a consolation which many American companies cannot enjoy.

Stable and low-cost foreign distribution can result from consistent application of engineering techniques by native administration.

DISTRIBUTION—THE NEXT FRONTIER

The operating results of a few companies, the lowered prices of a few commodities reported in this paper, are but a faint trail blazed through an unexplored wilderness of distribution underbrush.

But the blazed trail is the forerunner of every highway.

Fortunately, the highway of engineered distribution can be built quickly, once the top managements of American companies decide that distribution must be brought up to the factual level of production.

One company in two years with an "all-out" application of engineering techniques to one essential element of their distribution increased its operating profits from three to more than five million dollars. Simultaneously, this organization bettered its operating profit from sixteen per cent to twenty-one per cent with a drastic reduction of the average selling price of its products. This application of engineering technique in this company's distribution functions paved the way to both profits and lower prices within the short space of two years.

A thorough adaptation of proved engineering techniques to even a part of any company's marketing methods can yield direct benefits of sizable proportion within a short space of time.

> "On practical matters the end is not mere speculative knowledge of what is to be done but rather the doing of it." —Aristotle

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Contribution to the knowledge of distribution has been advanced by universities, foundations, and government bureaus whose research in this field has been consistent. The list is extensive, of which the following are representative:

United States

Bureau of Foreign and Domestic Commerce
Bureau of the Census
Harvard University, Graduate School of Business Administration
Ohio State University, College of Commerce and Administration
University of Michigan, School of Business Administration
The Brookings Institution.

Great Britain

London School of Economics
Empire Marketing Board.

The Netherlands

De Instituut.

An approach to the fundamental principles of the science of distribution is contained in the records of actual business experiences. A search has disclosed, to date, some 2867 case histories pertaining to this subject and the following represent some of the sources of these examples and collateral references.

While a mass of experience exists in case history form, the material has not been reduced to a set of principles which can form a practical kit of "tools" for the scientific mind.

It is the hope of the authors to continue the process of developing a body of principles from the material in existence. They will welcome the collaboration of all who are interested in widening this new field of business exploration.

Charles Phelps Cushing

BIRMINGHAM'S VULCAN

(This statue of Vulcan, 50 ft high, made of cast iron, and weighing 120,000 lb, stands on the top of Red Mountain, Birmingham, Ala., where the 1944 A.S.M.E. Spring Meeting will be held, April 3–5. See pages 212-213.)

Cemented-Carbide-Tipped
MILLING CUTTERS

Elements to Be Considered in Milling Steel

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ONE of the principal reasons for the long delay in the successful application of cemented carbides to the milling of steel has been primarily due to the fact that it was applied in exactly the same manner as it was applied to high-speed-steel cutters in the past. It was found that rigidity of setup, power, the proper cutting speed, and the proper tooth loading were of yet greater importance than with high-speed-steel cutters. It was also found that the positive cutting angles which are used for high-speed-steel cutters for milling steel were really fatal with cemented carbides, and slight progress was made until it was known how to apply cemented carbides properly to single-point tools for turning, facing, and boring interrupted cuts. This resulted in the use of the proper combination of positive and negative cutting angles and gave the first real clue to the successful application of cemented carbides to milling steel, because all milling cuts are interrupted cuts due to the nature of this type of machining operation.

In other words, the application of cemented carbides to milling cutters involves exactly the same basic principles as have been applied to single-point tools which take interrupted cuts. This will be shown by the aid of several illustrations.

Fig. 1 shows a piece of work mounted in the chuck of an engine lathe. The tool which is held in the tool post on the cross-slide of the lathe is taking an interrupted facing cut as shown in section A-A and is fed outward in the direction indicated. Note that the tool has a negative back-rake angle which prevents it from digging into the work endwise. This negative back rake allows the initial impact load when the work hits the tool to be taken, back from the nose of the tool, where the tool has its greatest strength. This type of setup tends toward maximum tool life.

Fig. 2 shows the same single-point tool taking another interrupted facing cut on the same lathe. The only difference between this setup and the one shown in Fig. 1 is that the work cross section which is being faced is much smaller. There is no reason why this tool should not stand up longer for this setup than for that shown in Fig. 1 because it is actually removing less material.

Fig. 3 shows a part which has the same cross section as that outlined in section B-B, Fig. 2. In this case the part is mounted on the cross-slide of the same engine lathe. A cutter body which holds the same single-point tool, as was previously referred to in Figs. 1 and 2, is mounted in the chuck jaws of the lathe. When the work is fed into the tool rotating as shown, an improvised type of fly-face milling cutter is obtained which will give fair results. It provides an excellent opportunity to study the action of the cutting edge entering the work, but this setup does not offer the rigidity of a corresponding setup on a milling machine.

Let us again consider a part which has the same cross section as the part shown in Fig. 3. In this particular case, the part is rigidly clamped to the table of a milling machine, as shown in Fig. 4. The same single-point tool, as was used in the setups shown in Figs. 1, 2, and 3, is clamped in a face-milling-cutter body which is mounted in the machine spindle and is rotated in the direction as shown. When the part is fed into this cutter we have an example of a cemented-carbide-tipped cutter in its simplified form and it incorporates the same basic features as outlined in the facing operation on the engine lathe in Fig. 1.

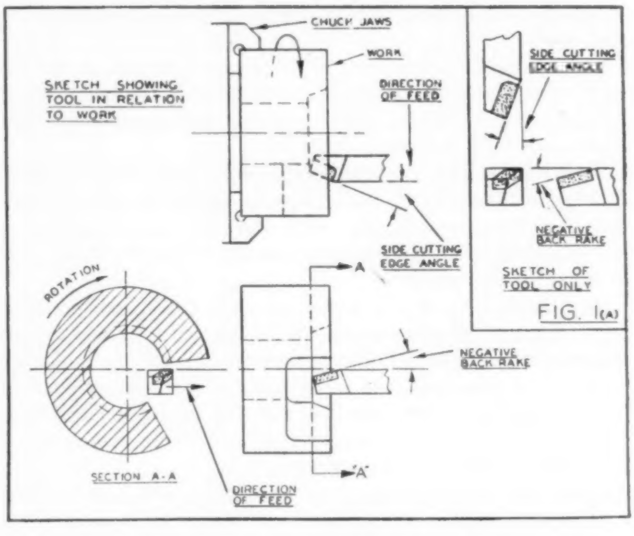

FIG. 1 SETUP IN ENGINE LATHE SHOWING TOOL IN RELATION TO WORK
(Insert shows sketch of tool.)

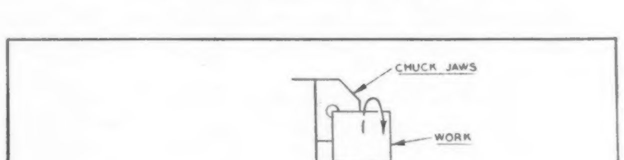

FIG. 2 SAME SINGLE-POINT TOOL AS IN FIG. 1, TAKING CUT ON WORK HAVING LESS CROSS-SECTIONAL AREA

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In other words, on all cutting tools the proper combination of the side-cutting-edge angle (bevel angle on milling cutters), the back-rake angle (axial rake angle on milling cutters), and the side-rake angle (radial rake angle on milling cutters) has a direct bearing on tool life since these three angles control the amount of protection afforded the cutting edge and the nose radius or chamfer. The latter is usually the weakest portion of any cemented-carbide cutting tool and must receive maximum protection. It is doubly important to protect the nose radius because it also maintains the size on the cut.

A general requisite to be remembered in applying cemented-carbide tools to interrupted-cutting (milling) operations is to build up sufficient back pressure through the design of the cutting tool to prevent the tool from digging into the cut in any direction and also to absorb all backlash in the machine before the nose radius or chamfer on the tool enters the cut. Failure to observe this simple consideration may be the cause of much unnecessary tool trouble.

DESIGN CONSIDERATIONS IN APPLYING CEMENTED CARBIDES

Axial Rake Angle (Negative). It has been shown that the application of cemented carbides to milling cutters involves the same basic principles as its application to a single-point tool which takes an interrupted facing cut. This results in the use of negative back-rake angles on single-point tools, and since the axial rake angle (see Fig. 5 which also shows nomenclature) on milling cutters is analogous to the back-rake angle on single-point tools, it also means that a negative axial rake angle should be used on milling cutters when milling steel. For this reason the cutting face of the teeth on milling cutters should be set at a negative axial rake angle to protect its nose radius or chamfer by allowing the entering impact load to be taken at some distance back from the corner of the tooth. This tends to build up a pressure between the milling cutter and the part it is machining and prevents it from digging into the part at the entering portion of the cut. The three different conditions shown in Fig. 6 may be encountered when the cutting edge enters the cut.

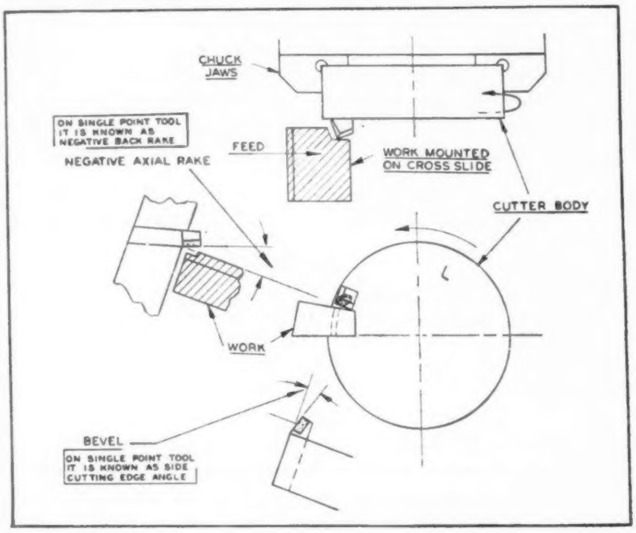

FIG. 3 IMPROVISED TYPE OF FLY-FACE MILLING CUTTER SET UP IN LATHE TO STUDY ACTION OF CUTTING EDGE ENTERING WORK

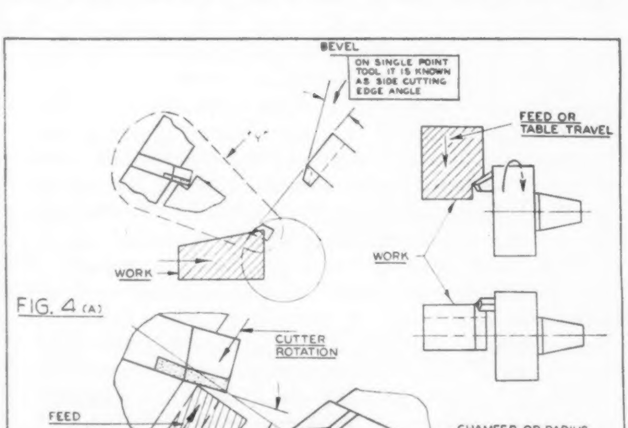

FIG. 4 SETUP OF CEMENTED-CARBIDE-TIPPED MILLING CUTTER IN SIMPLIFIED FORM

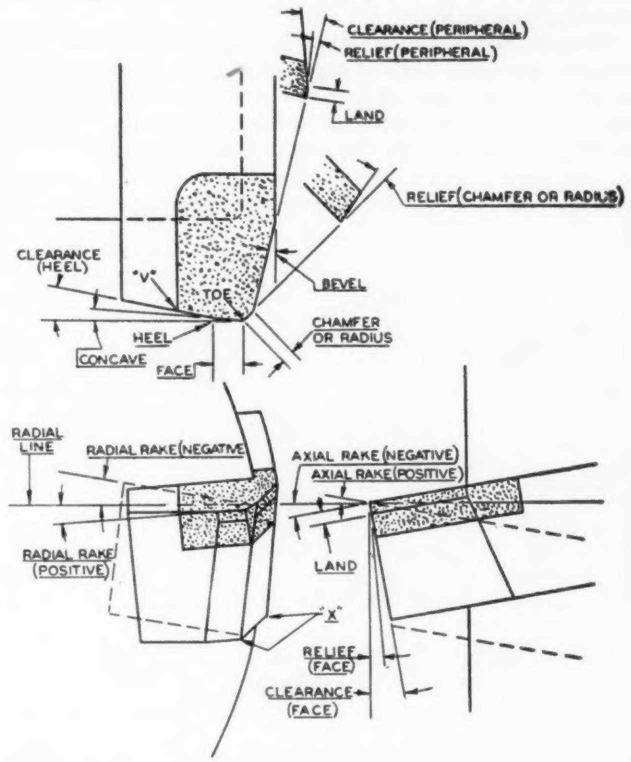

FIG. 5 DIAGRAM GIVING NOMENCLATURE FOR MILLING CUTTER WITH CEMENTED-CARBIDE TIPS

Fig. 6(*a*) shows the face of the work where the cutting edge entering the work is parallel with the center line of the milling cutter. The combination of the actual blade angle *B*, the radial rake angle, and the bevel angle (side cutting-edge angle on single-point tools) is such that it develops an effective negative axial rake angle *A*. If the effective negative axial rake angle is 3 to 5 deg greater than the angle on the face of the part, the cutting pressures will be held to a minimum and will tend toward maximum cutter life. If this angle is larger than necessary, it will tend toward increased power. The radius or chamfer should be the last portion of the cutting edge to enter the part.

Fig. 6(*b*) shows the cutting edge where it enters the cut as being parallel with the entering face of the part. This combination of the actual blade angle *B*, the radial rake angle, and the bevel angle is such that it develops an effective negative angle *A*, which actually matches with the surface on the entering side of the part. This creates the maximum impact load and tends to shatter the cutting edge. In other words, the entire cutting edge seems to break down at practically the same time. This condition should never be allowed.

Fig. 6(*c*) shows the radius or chamfer of the cutting edge as hitting the part first at the entering face of the part. This condition can develop from using too small an effective negative

axial rake angle which results from the wrong combination of actual blade angle B, the radial rake angle, and bevel angle. This will cause the radius or chamfer, which is the weakest portion of the cutting edge, to chip out or break down rapidly when it hits the part, due to the impact load. It is important that a cemented-carbide-tipped milling cutter never be used under this set of conditions, otherwise the cutter will have an exceedingly short life.

The axial rake angles in use at the present time usually vary between negative 3 deg and negative 15 deg. We recommend using 8 to 10 deg negative for face and straddle mills which cut past the part. For optimum cutter performance, a cutter should be designed with the proper axial rake angle to meet conditions outlined in Fig. 6(*a*). Experience on applications involving milling up to a shoulder indicates that a negative axial rake angle of approximately 3 deg retains the inherent advantage of a negative shear angle and at the same time assures the ability to hold the size on the part being milled by keeping the side pressure to a minimum.

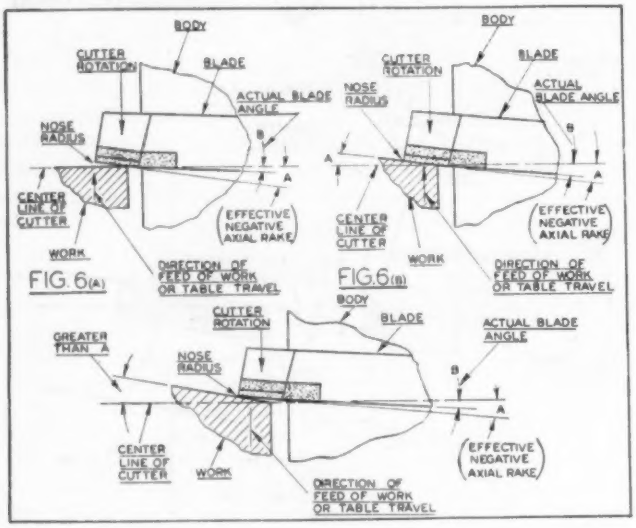

FIG. 6 CONDITIONS ENCOUNTERED WHEN CUTTING EDGE ENTERS CUT

Radial Rake Angle. The radial rake angle (see Fig. 5) is the angle which the cutting face of each blade makes with a radial line passing through the cutting edge. When the radial line in question coincides with or becomes parallel with the direction of the table travel, the radial rake angle becomes a measure of the free cutting action of the milling cutter.

Radial rake angles between 8 deg positive and 10 deg negative are being employed at the present time. The amount of radial rake varies with the nature of the application, and we consider negative radial rake angles as high as 10 deg to be extreme.

On milling applications, where the cutters mill past the work and bevel angles can be used, a positive radial rake is advantageous for soft steels and a negative radial rake for hard steels. Indications are to use about 8 deg positive rake for steels below 200 Bhn and gradually reduce the radial rake to 5 deg negative for steels in the 325- to 500-Bhn range. For operations involving milling to a square or almost square shoulder a negative radial rake of 3 to 7 deg should be used to assure maximum strength at the cutting edge even at a sacrifice of cutter efficiency.

In dealing with radial rake angles it should always be kept in mind that radial rake angles in the positive direction result in minimum power consumption and permit the use of deeper cuts and heavier feeds than negative radial rake angles. Only when really necessary should negative radial rake angles be used to strengthen the cutting edge, since their use results in a corresponding sacrifice in metal-removing efficiency.

Bevel Angle. The bevel angle (see Fig. 5) on a face- or straddle-milling cutter serves exactly the same purpose as the side cutting-edge angle on a single-point tool. It protects the chamfer or radius on the corner of the teeth when the face-milling cutter first touches the part and for that reason tends to increase the cutter life.

Fig. 7(*a*) shows a face-milling cutter with a 0-deg bevel angle entering a cut which has a 90-deg included angle as shown. This results in short cutter life because of the increased impact along the entire cutting edge including the chamfer or radius. If a slight bevel angle is ground on the cutter, as shown in Fig. 7(*b*), the initial impact load will be moved away from the weak chamfer or radius to a point of greater strength and the life of the cutter will be materially increased.

Fig. 7(*c*) shows the same face mill as was used in Fig. 7(*a*) for milling work which has an angle X on the entering side. Angle X at the beginning of the cut is comparable to a draft angle on a forging. This allows the chamfer or radius on the cutter to touch the work first and take the full initial impact load of the cut which dulls this portion of the cutter rapidly. The life of the cutter can be materially increased if a bevel angle 3 to 5 deg greater than the maximum angle X on the part is ground on the cutter. This permits the impact load of the cutter, when first entering the cut, to be taken at a strong portion of the cutting edge instead of the weaker chamfer or radius.

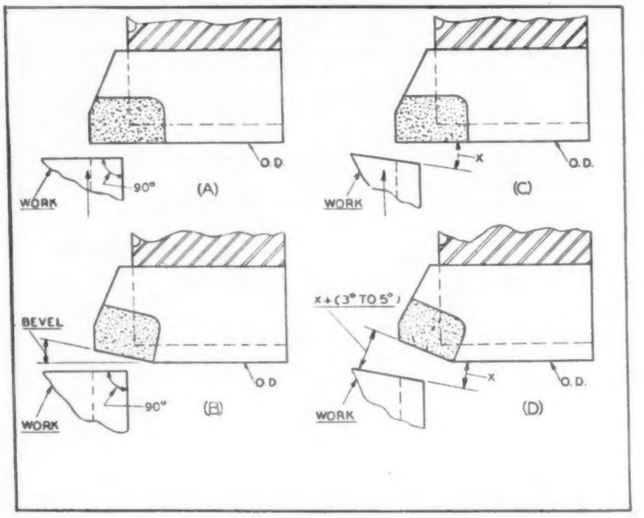

FIG. 7 CORRECT AND INCORRECT BEVEL ANGLES

For most face- and straddle-milling operations, where the cutter mills past the part, a bevel angle of 15 deg is usually satisfactory. However, where a 15-deg bevel is not sufficient to assure the chamfer or radius entering the cut last, the bevel angle should be increased up to as much as 35 deg if necessary. When a 0-deg bevel angle must be used, the radial rake angle should be 3 to 7 deg negative as previously mentioned. The width of the bevel angle should be sufficiently large to cover the full depth of the cut.

The relief angle (see Fig. 5) along the bevel angle or along the outside diameter should be ground between 4 deg and 7 deg up to an edge. Use 4 deg for the harder steels and gradually increase the relief angle until it is 7 deg for the softer free-machining steels. The clearance angle (see Fig. 5) behind the relief angle should be ground sufficiently large to permit the corners X to clear the cut up to a land $^{3}/_{64}$ to $^{1}/_{16}$ in. wide behind the cutting edge. If after the cutter has been used the land tends to widen rapidly due to wear, try increasing the relief angle. If the breakdown of the cutting edge is due to chipping, try reducing the relief angle.

Chamfer or Radius. Always grind a chamfer or radius (see Fig. 5) on all milling cutters to remove the extremely frail sharp corner which is inclined to flake off when the cutter is in use.

A radius gives the greatest strength and should be used if suitable grinding equipment is available and the finished work specifications permit.

Fly-Cutting Tools. Provide a radius on all fly-cutting tools. This can be easily ground freehand on all single-point tool grinders. A $^1/_{32}$-in. radius is recommended, ground at the same relief angle as on the bevel or outside diameter and the face. This radius may be enlarged, if necessary, for example, where work specifications indicate a large fillet.

MULTITOOTH CUTTERS

If work specifications permit, it is preferable to chamfer the teeth of multitooth cutters, as a chamfer can be ground more accurately than a radius with present-day equipment. A $^1/_{16}$ in. $\times$ 45-deg chamfer is recommended ground at about 1 deg less relief than on the outside diameter at the bevel. The two corners left by the chamfer should be brushed lightly with about a 320-grit silicon-carbide stone to remove the sharp corner. However, if an accurate tool-and-cutter grinder with radius attachment is available, radii should be ground on the cutter to give maximum strength. The radii must be ground carefully, assuring accurate tracking of the teeth.

If part specifications permit, the radius should be ground as shown in Fig. 8. This confines the angular movement W to

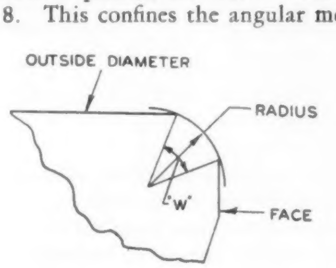

FIG. 8 CORRECT CONTOUR OF RADIUS FOR GRINDING

less than 90 deg and eliminates any chance of the grinding wheel digging into the cutting edge on the outside diameter or face. When no radius or chamfer is permitted, the corner should be broken slightly using a 320-grit silicon-carbide stone. Breaking the edge will eliminate much chipping otherwise encountered when the cutter enters the cut. A reduced number of pieces per grind usually results when no chamfer or radius is used.

If the relief angle alone is not sufficient to permit the corners X (Fig. 5) to clear the cut, grind a suitable clearance up to a land $^3/_{64}$ to $^1/_{16}$ in. wide behind the cutting edge. Generally this operation is unnecessary.

Face. The face of the cutter (Fig. 5) should be ground at 2 to 4 deg concave from the toe toward the heel, and the clearance below the heel should be ground at 5 to 7 deg, making the face $^1/_8$ to $^3/_{16}$ in. long. This increases the distance between the braze line V and the cut, and eliminates pickup of work material when the cutter is operating. When grinding the relief angle behind the cutting edge on fly tools, maintain the relief angle the same as on the bevel angle to simplify the blending of the radius.

When grinding multitooth cutters, the relief angles along the face should vary between 2 and 5 deg. Use 2 deg for the slotting type of cutter to aid in holding the slot width. A 5-deg angle is usually suitable for all other types of cutters. The face-clearance angle (see Fig. 5) should be 2 to 4 deg greater than the relief angle and should be ground up to a land $^3/_{64}$ to $^1/_{16}$ in. wide behind the cutting edge.

Tip Thickness. Minimum trouble is encountered if thicker carbide blanks are used for exactly the same reasons as for single-point tools taking interrupted cuts. Tip thickness for milling cast iron is fairly well established. As a practical rule use tips 30 to 40 per cent thicker when milling steel.

Grade of Cemented Carbide. A medium or general-purpose steel-cutting grade of cemented carbide is the best for general-purpose roughing and finish-milling of steel. Use a finishing steel-cutting grade for finish-milling where the depth of cut is not more than $^1/_{16}$ in. If the medium steel-cutting grade breaks down by chipping and all other conditions have been carefully checked suggest the use of a softer steel-cutting grade.

A finishing grade of straight tungsten carbide has been used to take extremely shallow finish cuts with a 0.005-in. depth of cut at unusually light feeds of less than 0.001 in. per tooth and will produce a surface smoother and flatter than a ground surface.

Speed. Observations indicate that higher speeds in feet per minute should be used when milling steel than are being used for turning, boring, and facing with single-point tools. These speeds vary with the hardness of the steels being milled. For 300 Bhn and under use 500 to 700 fpm, for 300 to 400 Bhn use 250 to 500 fpm, and for 400 Bhn and over use 150 to 350 fpm.

Feed. The optimum feed rate (table travel) in inches per minute for a given steel-milling job should always be determined from the feed-per-tooth basis rather than from the so often used "cut-and-try" method. A 0.005 to 0.008 in. feed per tooth will produce about the maximum number of accurately finished pieces per grind when using face mills or straddle mills which cut past the work. Lighter feeds per tooth can be used, but indications are that the number of finished parts per grind will decrease.

If the milling machine is in good condition and has ample power available, the fixture is rigid and is designed to bring the cut close to the milling-machine table; and if the milling cutter is properly designed, the feed per tooth can be increased to 0.015 in. without any detrimental effect on cutter life. When using slotting cutters or other cutters which cut up to a shoulder, indications are that a feed per tooth which is about 50 per cent of that used for ordinary face mills and straddle mills will give good results. This amounts to about 0.0025 to 0.004 in. feed per tooth. When this type of setup has real rigidity, the feed per tooth can be increased to about 0.008 in.

When the design of the part being milled necessitates that the corner of the cutter have a larger-sized radius, as heavy a feed per tooth as possible should be used to reduce the chip-thinning effect where the radius blends into the face, because it will increase the number of pieces per grind.

The feed rate (table travel) which can be used on any milling operation is dependent upon the following:

1 The number of teeth in the cutter.
2 The cutter speed in revolutions per minute.
3 The feed per tooth.

The final thought on the subject of feeds is that there would be fewer milling problems throughout the country if table travels were always determined from the feed-per-tooth basis; in other words

$$\text{Table travel} = \text{feed per tooth} \times \text{rpm} \times \text{number of teeth}$$

$$\text{Feed per tooth} = \frac{\text{Table travel}}{\text{Rpm} \times \text{number of teeth}}$$

Number of Teeth and Power. A large number of the milling machines in use today are limited in power and do not have motors larger than 5 to $7^1/_2$ hp. This restricts the work which can be handled satisfactorily with cemented-carbide-tipped cutters on these machines and it really becomes important that the power available be taken into consideration before starting any steel-milling operation.

The power which is required to mill a certain cut on a given

part on a given milling machine depends upon the following:

1 The revolutions per minute of the cutter.
2 The number of teeth in the cutter.
3 The feed per tooth.

The optimum feed per tooth and the optimum peripheral speed are quite definitely determined by the material being milled. This leaves only one variable, i.e., the number of teeth in the cutter to be considered to keep within the power available. It may quickly be found that the cutter can only have a small number of teeth and in many cases fly cutting (in which the feed per tooth is the feed per revolution of the cutter) may have to be employed as shown in Fig. 4.

The following formula provides a means of estimating roughly the number of teeth required in a milling cutter in order to keep within the power available:

$$N = \frac{0.56 \text{ hp}}{D \times F \times R \times W}$$

where

D = maximum depth of cut, in.
F = feed per tooth, in.
hp = motor horsepower
N = number of teeth in cutter
R = revolutions per minute of cutter
W = maximum width of cut, in.

A time-honored practice with high-speed-steel cutters has been to see that at least two teeth are in contact with the work at all times. At the higher speeds used with carbide cutters, this is not essential since there is sufficient momentum to assure smooth cutting action.

The following formula will give a rough estimate of the horsepower required for a given set of conditions:

$$\text{Hp} = 1.8D \times F \times N \times R \times W$$

The two foregoing formulas are based upon 1 horsepower being required to remove $^3/_4$ cu in. of steel per min. upon the cutter needing 35 to 40 per cent more power to take a cut when it is dull than was required to take the same cut when it was sharp.

DESIGN OF CUTTER BODY

The basic milling operations upon which cemented carbides have been used are as follows:

1 Face or straddle milling past the part.
2 Face or straddle milling along a shoulder.
3 Slotting.
4 Plain milling (very limited).

The various factors which must be considered in the design of these cutters are the workpiece, the cutting-edge angles, the speed, feed, horsepower available in the machine, and the number of teeth which can be used with this machine. It has been determined that the number of teeth and the horsepower tie closely together.

There are two general types of cutters which should be considered, i.e., solid, and inserted-blade types. Bodies can be made of steel or high-tensile cast iron. When a solid body is used ample chip room should be allowed and the carbide cutting edge should be rigidly backed up. There are cases where thin bodies are necessary, and in this case the solid type is the only one that can be used. The cemented-carbide blanks can be brazed directly to the solid cutter bodies by a low-temperature braze.

In milling steel with carbides, it is highly desirable to use a massive milling-cutter body in order to take advantage of the flywheel effect. This reduces the shock or rebound from the impact of the cutting edge against the work, provides a smooth cutting action, and results in an increased number of pieces per grind with less machine repair. It also enables the machine to level out momentary peak loads considerably greater than that of the rated motor capacity. When it is not possible to incorporate a sufficient amount of mass in the cutter body, auxiliary flywheels can be added to the spindles or arbors to smooth out the operation.

Diameter of Cutter. When determining the correct cutter diameter, it is desirable to take full advantage of the fact that the smaller-diameter cutters have to be run at greater revolutions per minute than larger-diameter cutters in order to obtain a given peripheral speed in feet per minute. The high revolutions per minute give more teeth per minute and permit a higher table travel for a predetermined feed per tooth. The small-diameter face mill helps to do a given job faster than the large-diameter face mill, because it reduces the length of the approach cut. In general the cutter diameter (as measured at the tooth radius or chamfer) should exceed the width of the work by 25 to 40 per cent.

The various conventional methods of holding the blades or tool bits in the cutter body can be used. Heavier blade cross sections should be used than for the corresponding sizes of high-speed-steel cutters.

Table 1 shows suggested blade or tool-bit thicknesses for various body diameters.

TABLE 1 BLADE OR TOOL-BIT THICKNESSES FOR VARIOUS BODY DIAMETERS

Body diameter, in.	Blade or tool-bit thickness, in.
$2^3/_4$ and 3	$^5/_8$
4 and 5	$^3/_4$
6, 7, 8, and 9	1
10 and larger	$1^1/_4$

The blades or tool bits should be allowed to project a sufficient distance from the cutter body to provide ample chip space, or clearance space must be milled in the body for the same purpose. This latter method is preferable on most applications, and it is essential wherever heavy cuts and heavy feeds are used. In any event the tools should never project beyond their support more than the shank thickness below the tip. In order to stay within this limit, it may be advisable to weld a steel support underneath and behind the blade or tool-bit positions before milling the tool slots.

All cutter bodies should be made to facilitate the free flow of chips from the cut. Any tendency to restrict this chip flow will reduce the number of pieces per grind and will ruin the finish on the cut.

FLY CUTTING

As mentioned under the subheading, "Number of Teeth and Power," it frequently may be found that, because of machine-power limitations, the desired feed per tooth, at optimum peripheral speeds for carbides, cannot be obtained with multiple-tooth cutters of ordinary design. This makes it necessary to reduce the number of teeth or use only a single tooth in order to obtain the proper load per tooth without exceeding the available horsepower.

Such single-tooth cutters are usually employed for shallow cuts through $^3/_{32}$ in. A typical single-tooth cutter is shown in Fig. 4. It consists of a tool bit mounted in a cutter body at proper angles previously referred to and ground to the outline in Fig. 5.

When the depth of cut is greater than $^3/_{32}$ in., it is advisable to increase the number of teeth but split up the total depth of cut into steps, with each tooth cutting a separate step. This gives a smoother cutting action and leaves a flatter surface than a single-tooth cutter. For example, with a two-tooth fly cutter, the teeth are spaced at approximately 180 deg. One tooth takes the heavy roughing cut, and the second tooth, the lighter finishing cut. The roughing blade or the tool bit is set ahead of the finishing blade radially a distance of $^1/_{16}$ in.

and the finishing blade extends axially ahead of the roughing blade.

Assuming, for example, that a total depth of cut of $^3/_{32}$ in. is being taken, the finishing blade takes a cut of only $^1/_{32}$ in.-depth, while the roughing cut removes $^1/_{16}$ in. In two-tooth cutters, a depth of finishing cut 25 to 35 per cent of the total depth of cut is generally satisfactory.

Much smoother cutting action can be obtained with fly cutting when applied to cuts $^1/_2$ in. deep or more if the number of teeth is increased to 3 or 4. In this case, the depth of the rough cut will be divided between 2 or 3 teeth which would still leave only one tooth for finishing.

When fly cutters are used, the blade or bits can be resharpened freehand on single-point tool grinders and set to a gage in the holder or body without removing them from the machine.

RIGIDITY IMPORTANT FACTOR IN MILLING OPERATIONS

The fundamental thought to be kept in mind at all times when considering any milling operation is rigidity. This applies not only to the machine but also to the method of clamping the work.

The Machine. Machines appropriate to the job and which are rugged enough to withstand all forces and shocks incidental to the operation should be used. The life and accuracy of the milling machine can be prolonged, the quality of the work can be improved, cost per finished piece lowered, and shutdown periods of the machine reduced, if the following suggestions are used:

1 All backlash in the feed screw should always be kept at a minimum. Machines with backlash eliminators should be used.

2 Table gibs should be adjusted to give the table a snug sliding fit.

3 End play in the machine spindle should be kept at an absolute minimum.

4 Because of the higher speeds and increased feed rates used with cemented-carbide-tipped cutters, lubrication should be checked to make certain that it is both adequate and properly applied.

5 Periodic machine inspections mean smooth accurate milled surfaces. Machine ways wear at their most commonly used sections, and therefore may be snug and at times sloppy, causing chatter, on cuts longer than normally used.

6 The knee and saddle should be securely locked before starting a cut.

7 When the tapered hole in the machine spindle is used to centralize a milling cutter, it should be clean in order that a uniform metal-to-metal fit for the full length of the shank is assured.

Fixture for Holding Work. The general nature of the work and the proper clamping of it have a direct bearing on the success or failure of any milling operation. The increased feed rates which are now possible with cemented-carbide-tipped cutters reduce the cutting time to an amount where loading and unloading time of the part being milled becomes a major problem. In other words the material-handling time becomes more of a problem than the milling time. The only way to correct this situation is to use fixtures with very heavy wall sections and actuate them rapidly by either air or oil pressure. The best arrangement is to use an automatic-cycle type of milling machine which has a fixture or fixtures which can be unloaded and loaded by the operator during actual cutting time.

The following points are of the utmost importance in good fixture design:

1 The ideal method of clamping any piece of work is to hold it rigidly but still allow it to remain in a state of "rest," without torsional or bending strains.

2 Clamp the part so as to keep the surface that is being milled as close as possible to the machine table.

3 If the surface being milled must be high above the table, the surface of the fixture taking the thrust should support the part directly behind the surface being milled.

4 A milling cut should be taken with both the cut and the table as close as possible to the spindle nose of the machine.

5 The milling fixture should be heavy enough to (*a*) absorb all the forces created by clamping and cutting without springing or deflecting the milling-machine table, (*b*) absorb the vibration developed by the cut.

6 The construction of the fixture should allow for the free flow of chips from the cut.

7 All cutting pressure should be against rigid stops and supports; never against the clamps.

8 Minimum distortion results if the point of clamping is as nearly as possible opposite the point of support.

9 Where work sections are thin, it may be necessary to provide additional locking spring plungers, or similar devices, to support the work adequately.

10 All milling fixtures should be aligned with the table slots by inserted keys on the bottom of the fixture.

11 Equalizing clamps should be used to provide for variations in size and shape of the part.

12 All locating and supporting surfaces of a fixture should be permanently fixed, or have adjustable fixed stops. Only the clamping surfaces should be movable.

13 The bottom of the fixture should be cleaned and all nicks and burrs removed before clamping it to the milling-machine table.

14 The points of location and support should be no larger than absolutely necessary and positioned near the extremities of the part but still as close as possible to the surfaces being milled.

15 Burring time can be reduced to a minimum on parts which require several cuts if the direction of the feed and the various cuts are positioned so as to throw as many of the edges as possible requiring burring on the same side of the part.

16 Where it is necessary to clamp the work from the sides, the clamps should also pull the work against the supports.

17 When a stop and a support surface on a fixture form a sharp corner, the corner should be relieved to reduce the tendency to catch dirt and to simplify cleaning.

18 When clamping, use wrenches on fixtures designed for them, and hands only on hand knobs.

OPERATING PRECAUTIONS

The following precautions should be observed when using cemented-carbide-tipped cutters:

1 Never disengage spindle while feed is engaged.

2 Always have the cutter rotating before feeding the work up to the cutter.

3 When using machines with rapid traverse make certain that the rapid traverse is out and the regular feed in before the work contacts the rotating cutter.

4 When stopping the machine, first throw out the feed and then immediately disengage the spindle clutch.

5 Never allow the cutter to idle in the cut, as the rubbing of the cutting edges against the work has a lapping effect on the cutting edges which dulls the cutter.

6 Keep the cutter rotating when returning the table to starting position after a roughing cut.

7 After a finish cut, the work should be removed before returning the table. When face-milling on a universal knee type of milling machine, the table must be set at zero position. The table should travel normal to the center line of the cutter spindle, or be set to travel slightly past at an angle equivalent to 0.002 in 18 in., so that the trailing portion of the cutter will not spoil the work. When face-milling on a plain-type milling machine of either the horizontal knee or the vertical type, the angular relation of the milling-machine spindle to the direction of table travel is such that the trailing portion of a cutter which

is properly ground will not spoil the finish on the work. This also applies to the manufacturing and planer-type of milling machine. Chips always should be wiped from the ways before moving the table saddle or knee.

Dragging Work Across Cutter on Return Stroke. Indications are that increased cutter life is obtained when the work is not dragged across the cutter on the return stroke. The main reason is that the milling cutter builds up a pressure between the work and the cutter to the extent where the cutter actually takes a cut which is shallower than the machine setting. On the return stroke the work and cutter assume their normal position which means that the cutting edge drags across the work. This ruins the cutting edges and causes chipping when the cutter is not rotating.

If the work cannot be removed before it is returned to the starting position, the cutter should be kept rotating on the return stroke. This will permit it to cut its way across the work. This is liable to ruin the finish on the work and also increase the wear on the cutting edges, but even so it is better practically than to drag the cutter across the work without rotating. The ideal type of cemented-carbide-cutter setup is one where either the cutter is automatically moved to clear the work or the work moved to clear the cutter on the return stroke.

Cutting Dry Versus Cutting Wet. All indications are that the best cutter life is obtained when milling steel dry because the chips are thin and the major portion of the heat flows into them until they seem to approach a plastic state. In this condition they seem to wear the cutting edge much less than when they are chilled by a coolant.

Chip Removal. All cutters must be designed to give the chips unrestricted flow from the cut, otherwise they will develop added heat and become troublesome. This may become a real problem and should be given careful consideration when deciding upon the proper number of teeth in the cutter. Always provide ample chip space.

If proper consideration has been given to chip space, and the chips are inclined to stick to the cutting edge, there is always danger that they will ruin the cutting edge when they hit the work again. It is suggested that a strong air blast be directed against the cut, to remove the chips as they form. Chips have been removed from face-mill cuts by directing an air blast through the machine spindle and the center of the cutter at pressures as high as 150 psi.

The flying chips which result from the high-speed milling of steel with cemented-carbide-tipped cutters can become a hazard to the operators in the vicinity of the milling machine where the work is being done. These can be easily controlled if simple chip guards are installed on the machines in question.

Climb Milling Versus Conventional Milling. Indications are that increased cutter life is obtained with "climb milling." This idea can be applied to all types of milling cutters which mill up to a shoulder when contrasted with cutters which cut past the work.

The main reason for the improved results from climb milling is that every tooth takes a chip of a definite thickness at the time it enters the cut. With conventional milling (also known as up-cutting) every tooth starts with a chip which has a zero thickness and reaches its maximum near the end of its cut. This maximum chip thickness is practically the same as the chip thickness at the beginning of the climb cut. At the beginning of a climb cut, each tooth actually cuts a chip, whereas at the beginning of a conventional cut there is an abrasive action until sufficient pressure has been built up to where the cutting edge penetrates the work.

All milling machines are not designed for climb cutting, therefore this idea must be applied with caution. Machines with a backlash eliminator in the feed nut can be used for climb-milling.

Face Milling Versus Plain Milling. Wherever possible, face mills or straddle mills should always be used in preference to plain mills because they operate with reduced cutting pressures. This permits the use of increased feeds and results in longer cutter life. A plain mill involves problems in design and manufacture since it is difficult to maintain a uniform rake angle with cemented-carbide-tipped cutters because of the cutter width. These problems do not exist when considering the face mill or the straddle mill.

Cutter Grinding. The surface condition of any machined surface depends to a large extent upon the accuracy with which the cutting tool for machining the work has been ground. For this reason, it is essential that the proper technique for grinding cemented-carbide-tipped cutters is followed if the maximum results are to be obtained. The relief, clearance, and concave angles should be ground to specifications outlined under bevel angle, chamfer or radius, and face to give the best results, or be modified slightly if necessary.

All single-point tools used for fly cutting should be ground freehand on single-point tool grinders. Use 60- to 80-grit silicon-carbide wheels for rough-grinding both the carbide and steel. Use 180- to 220-grit diamond wheels to finish-grind the carbide tip only to produce a smooth and keen cutting edge.

All multitooth cutters should be ground on any tool-and-cutter grinder which is equipped with a suitable rugged fixture. The machine must be kept in first-class condition with a free-running but snug spindle, snug gibs, and straight and true ways. Either the cup-wheel or straight-wheel method of grinding is satisfactory. Use the same-grit wheels as mentioned for fly-cutting tools.

Before fly cutters or multitooth cutters are used, the cutting edges should be brushed lightly with a 320-grit silicon-carbide stone at a 45-deg angle to the face of the tooth to remove any feather edges left from the grinding operation.

Cutter runout should always be checked before using any multitooth cutter. For best results it should be kept within the value shown in Table 2. When inspecting runout on outside diameter, no consecutive tooth should have a variation greater than one half of the total runout.

TABLE 2 CUTTER RUNOUT FOR MULTITOOTH CUTTERS

	Permissible runout			
	Roughing cuts		Finishing cuts	
Cutter diameter, in.	Face, in.	OD and chamfer, in.	Face, in.	OD and chamfer, in.
Up to 12	0.001	0.002	0.0005	0.0015
12 to 16	0.0015	0.003	0.00075	0.002
Over 16	0.002	0.004	0.001	0.0025

When several cutters have the same number of teeth and are mounted on an arbor so that they will mill several surfaces or several parts at the same time, a much smoother cutting action will be obtained if the cutters are keyseated to stagger the teeth. This will increase the number of pieces per grind.

If the cutter is not located properly in relation to the work when face-milling a part, an objectionable burr may develop on the side where the cutter enters the work. This can usually be eliminated by increasing the cutter overhang, on the side where the burr develops, by a slight amount.

All multitooth carbide-tipped milling cutters are usually difficult to handle because of their size, shape, and weight, and therefore cutting edges are often damaged through careless handling.

Special wooden boxes or trays, built to fit each size of the cutter, with covers which can be fastened in place by screws, aid in eliminating this difficulty. Such containers are used by many plants today for storing cutters and for transporting them from storage to machines, grinders, etc.

The cutting edges on single-point tools which are used in fly-cutter bodies are also easily ruined by improper handling. This can be eliminated by providing suitable boxes to hold several of these tools in a vertical position.

The Value of

"TEAMWORK"

By J. F. LINCOLN

PRESIDENT, THE LINCOLN ELECTRIC CO., CLEVELAND, OHIO. MEMBER A.S.M.E.

THE foundation of any incentive payment system is to make the worker feel that he is part of the team and that he profits proportionately from the success of the organization. We think of incentives as something new, but actually, incentive has been responsible for all the progress that this world has ever made.

Present-day evidence of how properly applied incentives have increased productive capacity to an unbelievable extent is evident in those places where labor and management have arrived at an arrangement of complete co-operation. With such unified effort, production rates of more than several times that in other plants where incentive is absent, are usual. But we are in a position of not recognizing how important incentive is in the production of human beings through failure to develop the latent capabilities they possess.

This philosophy may aptly be termed "intelligent selfishness" and can be explained as follows:

There have been many who have guessed what the result would be if a large, intelligently led, enthusiastic organization should use the powers latent in all the individuals to a common end. What would happen when all are equally anxious to produce a product at the lowest possible cost? What would happen when all want to make the wages of all workers, from sweeper to manager, a maximum? What would happen when all want to make the company profitable since it is largely owned by the workers in it?

This cannot be done by human beings except by the exploitation of the driving force fundamental in all of us, namely, selfishness. Selfishness has a bad reputation but that is because of a narrow conception as to what it really is. No program involving the human race developed as it has been through the ages on the concept of the "survival of the fittest" can be founded on any other principle than selfishness. The only necessary corollary to this principle to make it attractive, helpful, and satisfying to all concerned is to make this selfishness intelligent. The greatest heights we attain as humans, patriotism, parenthood, and friendship, are all based on this same human trait—selfishness. The results which can occur when this incentive is tapped are illustrated by the example set by our company.

Our company was started by one man with a capital of $150 of borrowed money in 1896 and has had no outside capital since. The company has tried to follow the principle of appealing to the intelligent selfishness of the worker, the manager, and the investor. It has gone along its unique path for a long enough time so that its results are proved. There is sufficient history back of the facts so that no error can be made in appraising the outcome.

Over a period of years our company's incentive plan has reduced the selling price of its arc-welding products as much as 87 per cent and, at the same time, increased the earnings of its workers in proportion to their productivity. The average annual wage of the Lincoln worker for the past 13 years shows that he was paid a consistently higher rate than the average wage of the worker in the machine-tool and the electrical-machinery industries. Averaging approximately $2100 per year in 1929, our workers through intelligent application of the incentive principles, have increased the average to an annual earning of over $5000 per year in 1941 and 1942, the outcome of a boost in productivity over nonincentive workers of several hundred per cent.

How much a worker develops will depend upon the incentive, the price he gets, and the desire or determination on his part to rise to any point that his ability will permit.

As a further explanation of how the individual reacts to a properly applied incentive system, the worker is influenced to do his job as well as he can and co-operate with the rest of the organization so that he can get his work done in the shortest time.

You have probably heard labor referred to as a commodity, something you can buy in the open market for as little as you can pay, keep as long as you want, and then discard when you are through with it.

But labor is not a commodity. Labor is made up of individuals who have the same desires as yours and mine and everybody else's. A laborer is a man who has to support himself and, generally, a family; a job that is very difficult and one which occupies most of his attention and a great deal of his feeling.

Treated as a commodity, he will react as you and I would. He will try to give as little as he can for as much as he can get. His mind will be fixed with the one fundamental thought that there is a certain amount of work to be done and the slower you do it the longer it will last. Therefore, he will not overlook the many ways in which he can spread the job out.

An incentive system can change the worker's point of view, because with the proper incentive, he wants to get the work done as quickly as possible, to do it accurately and with a minimum of waste. Through appeals to his "intelligent selfishness," he becomes a part of the team, knowing that his profit will increase in proportion to the success of the company.

The reasons why incentive-wage-payment systems are being retarded in this country are obvious. As far as worker and management are concerned, there would be little difficulty in arriving at a goal of complete unity of purpose were it not for government interference.

We recently refused an assessment levied against us by the Navy Price Adjustment Board in connection with renegotiation of war contracts. This unconstitutional action has been challenged by us.

J. F. LINCOLN INSPECTS NEW MODEL GAS-ENGINE-DRIVEN WELDER

American industry cannot go on with the present government-inspired class consciousness which holds that no man who works with his hands can be paid more than $5000 a year regardless of what he produces. No industrial system can develop to its maximum when government insists that if workers produce four times as much as others, they must be paid the same amount because they belong to the same class.

The present Administration is accountable for many mistakes; none more serious or more deadly than that of reducing efficient workers to the level of the inefficient.

Contributed by the Management Division and presented at the Annual Meeting, New York, N. Y., Nov. 29–Dec. 3, 1943, of The American Society of Mechanical Engineers.

The GROWTH PAINS *of* INDUSTRIAL PSYCHOLOGY[1]

By DOUGLAS McGREGOR

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AS THE problems of industrial relations become more and more complex, it is inevitable that industry should turn to the psychologist, with increasing insistence, for help. This insistence is beginning to bear fruit, but the fruit is as yet seldom available in the form of books which the layman can readily digest. Industrial psychology is a field that has had, from a hard-boiled, practical point of view, an unfortunate history. Examination of the literature of the past two decades leads one to the conclusion that the industrial psychologist has consistently attacked only those problems for which he had already developed "measuring instruments." Given the intelligence test, and other measures of individual differences in aptitude, he attacked certain problems of employment selection. Given fairly well-developed methods for studying learning, he approached the problem of industrial training. Given a whole set of techniques for measuring sensory phenomena, he studied the effects of illumination, noise, posture, and the like upon the productivity of workers.

BASIC PROBLEMS—HUMAN RELATIONS

All this work is of unquestioned importance, but one can hardly be blamed for offering the criticism that industrial psychology has failed to put first things first. After all, regardless of the aptitudes of industrial employees, regardless of how well we teach them job routines, regardless of the effects of illumination and humidity on their output, the industrial organization remains a complex series of relationships between people who must get along together somehow. The basic problems of industrial psychology are problems of ***human relations***. Until we understand these relationships and their consequences, the number of units of illumination on the workbench is probably not of very great importance.

During the recent past, psychologists have begun to approach the basic problems of human relations in industry even though they had few adequate tools (in the form of measuring instruments) with which to work. They did have insight gained from a wealth of clinical experience, and some tentative, but well-formulated theories. After the pioneer work of the Harvard Business School group at Hawthorne, many other investigators turned their attention to the problems of human relations in the factory. And it soon became apparent that the more academic branches of social psychology and abnormal psychology, as well as the clinical fields of psychiatry and psychoanalysis, had much to offer.

Robert McMurry's book[2] is one of the first (except for some rather superficial, popular volumes) to approach industrial psychology from this new point of view. It must be admitted that the author does not attempt a thorough and detailed analysis of the phenomena he discusses. It is probably too soon for that. There is so much ground to cover, and one cannot avoid the constant temptation to try to say everything at once.

Perhaps the chief difficulty that the lay reader will encounter in reading this volume is one that no author has yet surmounted. Until an individual has had the actual experience in a psychotherapeutic situation of gaining insight into his own peculiar emotional quirks, the explanation of theoretical concepts in this field seems somewhat absurd. We humans cannot comfortably accept the lack of logic in our behavior. To be "sensible" (i.e. to behave in a logical, intelligent fashion) is not simply praiseworthy; it is, we feel, natural and necessary. The fact that most of our logic is *ex post facto* does not occur to us. The real nonlogical emotional basis of our behavior, when pointed out, seems somehow unnatural and unbelievable. We have turned nature upside down, and considered rationally motivated behavior to be the rule. It is, in fact, the exception, even among those of us who consider ourselves to be highly intelligent.

As a result of this understandable desire to endow mankind with those virtues which raise him well above the rest of the animal kingdom, we tend to be resentful when the emotional nature of our behavior is pointed out. It requires a convincing demonstration, upon material drawn from our own personal lives, to bring us down to earth. McMurry's discussion will meet with resistance, in a degree proportional to the reader's unconscious desire to protect himself against the realization of his own irrationality.

The author introduces such terms as "reaction formations," "anxiety," "self-destructive tendencies" and "hostility toward authority," frequently with no more than a parenthetical phrase of explanation. It is improbable that a useful understanding of any one of these terms can be acquired without pages of illustration and discussion. And even then, the reader's own unconscious prejudices may blind him completely to the important implications which remain unstated.

If the reader can lay aside his preconceptions about human behavior, and accept what may be to him a somewhat novel set of explanatory principles, he will undoubtedly acquire many new insights into some of the causes of strife and friction in industry. The tactics utilized during the organization of labor unions, the apparently absurd demands sometimes made by workers, the blind hostility expressed frequently toward management, the lack of co-operativeness of labor under conditions where co-operation would seem to be an obvious necessity—these and many other aspects of the behavior of workers, and of management also, are not due to mere cussedness, or to a stupid refusal of people to recognize their own self-interest. There are reasons—good ones—for all these odd and apparently unintelligent actions. The author has exercised considerable skill in pointing to these reasons, even though his discussion of them is sometimes too brief.

INTERPRETATION OF RESULTS

The author attempts to provide a few ready-made tools for attacking some of the problems of industrial relations. These consist primarily of some sample questionnaires and interviewing schedules. However, it is frequently true that unless a questionnaire is tailor-made to fit the problems of the organization, it will not yield the desired information. Usually, by the time the investigator knows what questions to ask, he has already acquired the meat of his answers—qualitatively at least.

(*Continued on page 202*)

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "Handling Personality Adjustment in Industry," by Robert N. McMurry, Harper & Bros., New York, N. Y., 1944, xi and 297 pp.

CHIP CONTROL *With*

Sintered-CARBIDE-TIPPED TOOLS

By MALCOLM F. JUDKINS

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REGARDLESS of the type of machining operation or of the part being machined, one of the products is chips. For example $^1/_2$ cut 0.04 fpr 200 fpm will produce about 1000 lb of chips per hour. The control and disposal of chips is accordingly an important matter.

Sintered-carbide-tipped tools cut at exceedingly high speeds and the chips are hot, sharp, and in rapid motion. Chip control and disposal are necessary to safeguard the machine-tool operator, to keep the machine clear, and to facilitate the handling and salvage of chips for remelting. Moreover chip control has a decided effect upon the quality of the machined surface, the accuracy, power consumption, and tool life.

The type of chip is dependent upon the nature of the material being machined and the cutting conditions. Normally, weak brittle materials produce discontinuous chips, which require no control. Strong, ductile materials produce continuous chips and require positive means of control, except in the case of cuts of short duration. A chip groove is no more needed for an intermittent cut than in the case of face milling.

Our concern is, therefore, not with metals like cast iron or with other low-strength materials, such as plastics, which while abrasive do not offer a high degree of cutting resistance. Chip control becomes of great moment, however, in the machining of steels and other dense or highly alloyed, tough, ductile metals.

Chip formation in the cutting of ductile materials is largely a matter of compression followed by bending, shear, and plastic flow. High-strength materials tend to form tenacious and coherent chips which must be coiled or broken into fragments or pieces which can be removed, controlled, and disposed of with the greatest over-all efficiency and economy.

FACTORS IN CHIP FORMATION

The conditions which are conducive to the formation of a discontinuous chip are a brittle material, a thick chip, i.e., coarse feed, a low cutting speed, and a small rake angle. Conversely, the conditions which tend to produce a continuous chip are a ductile material, a thin chip, i.e., fine feed, a high cutting speed, a steep rake angle, a keen cutting edge, the optimum temperature at the tool point, and minimum resistance to chip flow across the tool face because of a high polish on the tool face, the use of an adhesion-preventing medium, such as a cutting fluid, and a low-coefficient-of-friction tool material.

In conventional turning, the vertical component of the cutting force acting normal to the tool face is the largest single factor. Maximum shear occurs at 45 deg to the applied force, and lateral flow, in the case of neutral rake, must occur almost at right angles to the principal force. Under these conditions frictional resistance is naturally a maximum. The escape of the chip from the region of the tool point is further impeded if we inject still another obstacle to chip flow in the nature of a groove or other means of deflecting, coiling, or breaking the chip. Obviously, the built-up edge which is always present to some degree whenever a ductile material is cut is greatly accentuated by any means of chip control which impedes chip flow away from the tool point. Not only does the curling chip tend to scratch the machined surface but the unusual size and shape of the built-up edge, engendered by the means of chip control which is employed, also adds to the roughness of the cut surface, because of the escape or adhesion of fragments of the built-up edge on the machined portion of the work. The escape of parts of the built-up edge between the tool and the work likewise abrades the flank of the tool beneath the cutting edge and accelerates the dulling of the tool, thus materially shortening the tool life.

METHODS OF CONTROLLING CHIPS

The first measure that should be tried in an endeavor to control the chip, especially in the case of light finishing cuts, is the double-negative-rake angle. This method has much to recommend it. First, of course, is its ease of grinding, which can be done freehand on tools with neutral or even positive rake by presenting the tool point to the flat of a grinding wheel so that a triangular surface at the required negative side and back-rake angles is ground to an extent which will accommodate the required depth of cut. Obviously, this form of chip control lends itself to greater ease of honing, lapping, or other polishing than any other. The difficulty of refining the surface of the chip-control groove is in fact one of the main sources of criticism of the conventional ground-in chip groove. The double-negative-rake surface functions as a means of chip control by deflecting the chip, causing it to strike the uncut surface of the work ahead of the tool point. This action either curls or breaks the chip.

Occasionally the right combination of side and back rake, depth of cut, feed, speed, and cutting-edge contour will coil or break the chip.

If more positive means of chip control is needed, an applied chip deflector or breaker can be tried. A hardened-steel or sintered-carbide-tipped member may be clamped, screwed, or otherwise held in the proper position on the tool face. It is desirable to provide means of adjustment, because the location of the deflector with respect to the cutting edge of the tool will naturally change with the depth of cut, feed, and speed, as well as with the nature of the material being cut. The applied chip breaker or deflector is in any event a serious obstacle to chip flow, and the escape of the chip from the tool point. The chip also has a tendency to get under the chip deflector causing jamming, resulting in either tool breakage or shearing of the screws or other supports by which the deflector is held in place.

GROUND-IN CHIP GROOVE

The most successful and the most widely used form of chip-control measure is the ground-in chip groove. This is a step, groove, or other type of depression ground into the tool face near the cutting edge. This groove can be applied to tools having negative, zero, or positive rake. Inasmuch as the required rake angle is ground into the groove itself and since the chip touches only the surfaces of the chip groove and not the balance

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of the top or face of the tool it is customary to mount the sintered-carbide tip horizontally or flush with the top of the tool shank.

In action the chip traverses the rake surface of the chip groove and is deflected into a coil or broken by means of a shoulder radius at the inner edge of the chip groove. This shoulder radius is highly important. If a sharp corner were to remain at the inner extremity of the chip groove stress magnification would result in the shearing off of the tip beyond the groove. Furthermore the moving chip encountering a dead end in its passage across the tool face could escape from the tool point only by upsetting or buckling. This would impose a definite back pressure on the edge of the tool tending to failure by spalling or chipping.

The ground-in chip groove may take several different forms. When the depth of cut is variable or if turning must be done to a deep shoulder the chip groove may be ground parallel to the side cutting edge. For general rough-turning this type will give satisfactory results, but the chip will probably be in the form of a nearly continuous helix or coil which can be directed through the bed openings of the lathe to the chip pan. Grinding the chip groove at an angle to the side cutting edge will restrict the diameter and length of the chip coil produced and in many cases, the chips will be in the form of very short lengths less than 1 cycle of the helix of the curled chip. In this form chips of tough, ductile materials such as highly alloyed steels present no more of a handling or disposal problem than the chips from gray cast iron.

For very light finishing cuts with fine feeds, the chip groove may be ground at about 45 degrees with the side cutting edge. A very small nose radius and a narrow groove width will result in exceedingly small chip fragments. Care must be observed, however, or premature tool failure from shearing of the extreme tool point may occur. The double-negative-rake-angle type of chip control previously described will usually give better results.

In any event the chip groove need not exceed 0.015 in. depth and its width should be about five times the feed per revolution. The groove must not get too deep when resharpened, In order to protect the cutting edge of the tool from failure in heavy roughing and intermittent cuts it is advisable to start the chip groove back from the edge a distance equal to the feed per revolution.

Any form of chip control which in any fashion interferes with the removal or escape of the chip will increase the power consumption of the cut being taken. Frequently power limitations will prohibit the use of any means of chip control. If the cut taken by each tool is of only short duration or extent and interference with other tools in the setup can be avoided the machine may be cleared of the long, stringy chips at the end of each cycle, although this obviously adds to the machining time per piece.

PROCEDURE FOR GRINDING GROOVES

Chip grooves can, in an emergency, be ground freehand but much better and more consistent results are realized by using one of the various makes of chip-groove grinders now available or by using a suitable vise or fixture in a surface or tool and cutter grinder.

As in all rigid grinding of sintered-carbide chip grooves should be undertaken only with diamond-impregnated grinding wheels. Usually, rough-grinding can best be performed with a 100-grit wheel, using a 220 or finer grit for finishing. Lapping or polishing of the chip groove after final grinding is highly recommended. Ordinarily, the scratches from grinding and polishing the surface of the chip groove are nearly at right angles to the direction of chip flow. Anything that can be done to rectify this condition or even to diminish the depth or width of the scratches will improve performance and reduce resistance to chip flow. Using a rather small-diameter grinding wheel swung out of the path of the table travel will alleviate this condition by making the scratches at less than a right angle to the direction of chip flow. Lapping with diamond dust and a suitable vehicle such as olive oil will also be found beneficial. Any time spent in refining the quality of the cutting edge and the chip impingement or rubbing surfaces will be amply repaid in improved performance and remarkably extended tool life.

In spite of all that can be said beforehand experience with each particular application is still the best criterion of which form or type of chip control should be practiced. In the last analysis, the determining factor lies in the answer to the question: Does it work?

The Growth Pains of Industrial Psychology

(Continued from page 200)

With respect to interviewing schedules, the basic problem is of course the interpretation of the results. The author makes a brave attempt to aid the reader along these lines, but there is really little he can do in the absence of skilled analytic insight on the part of the reader. Interpreting interview material is a highly developed technical skill today.

The other chief criticism that must be leveled at this book is the absence of an integrated theory. Again, however, the author's difficulty is a function of practical necessity and of the newness of the approach. The explanation of the phenomena under consideration is in terms of a number of relatively isolated principles. While the principles themselves are sound enough, they do not "hang together." They are in the nature of rules of thumb. The trouble with rules of thumb is that they frequently do not fit the individual case. Given an integrated theory from which these principles were derived, this criticism would not matter, for the reader could always fit the specific case to the general theory and derive his own principles. Lacking the theory, the principles are inadequate because the actual problems of industrial relations are always sufficiently unique so that no rules of thumb quite cover the case.

By limiting attention to one coherent set of phenomena—for example, the circumstances underlying the organization of labor unions—it would be possible today to present an integrated systematic theory which would "explain" a great many related happenings. The theory might require modification as experience accumulated, but the theory would be there and it could be tested against every new happening. Without a coherent theory, the reader has nothing but some isolated principles which will seldom yield sufficient understanding of a specific series of events. Moreover, many of these isolated principles will sound to the lay reader like unfounded assertions, whereas the principles emerging from a systematic theory would carry much more conviction. If the author were to provide the reader with the necessary arguments and illustrations to support his principles, he would in the process develop a theory. But his book would by then have become several large volumes.

For the open-minded layman who senses a lack in the traditional approach to the problems of industrial psychology, this book may be a real help. He should not, of course, expect this new approach to be a panacea. We know a lot today, as McMurry indicates, about the reasons for some of the more important problems of industrial relations. However, the complexity of the human personality precludes the possibility of simple solutions to these problems.

The most one can hope for is that increased insight will provide the reader with greater skill as he approaches his own day-to-day experiences.

E.C.P.D. Proposed CANONS *of* ETHICS

By D. C. JACKSON

CHAIRMAN, E.C.P.D. COMMITTEE ON ETHICS; FELLOW, A.S.M.E.

At the 1943 Annual Meeting of The American Society of Mechanical Engineers, the Council voted that it "feels strongly the desirability of a common code of ethics covering more than one branch of the engineering profession, and puts itself on record as willing to co-operate in any joint action in that aim." It also voted that it "approves in principle the Code of Ethics as presented by the Engineers' Council for Professional Development" which is printed herewith. The specific consideration of that code, known as "Proposed Canons of Ethics for Engineers," is now in the hands of the A.S.M.E. Committee on Professional Conduct. Thus it is appropriate to publish these canons so that all members can see what is under consideration.

Canons of Ethics for Engineers state rules of right conduct under the professional conditions relating to engineering. These proposed canons have been worked out after a long period of consideration and study by an engineers' joint committee on ethics, composed of individual members appointed by each one of the constituent societies associated with E.C.P.D. and the American Institute of Consulting Engineers (A.I.C.E.), each society being represented by one such appointee.

This committee was originated in the days of the American Engineering Council and the six individual members of the committee were appointed by six constituents of that organization. When A.E.C. was dissolved, E.C.P.D. assumed sponsorship of the committee and the three additional constituent societies of E.C.P.D. appointed representatives as members of it. Each committee member has been an important officer in the society which he represents.

The committee reported a formulation of 31 items to E.C.P.D. Upon considering these items, E.C.P.D., which is an advisory body, submitted the formulation to each of the nine societies with its proposal for adoption and the request that each society make comments and particularly that each name any item in the formulation which could be appropriately omitted, and propose any item or items, not in the formulation, which ought to be there.

The object of a uniform formulation of ethics in the engineering field is to secure a higher degree of professional recognition of engineering by the people of the United States and to serve as a guide to professional conduct for engineers. Even the engineering schools at the present time are vacillating in respect to the professional quality of engineering; and it has been often said that engineering cannot be considered a profession unless and until it can clearly formulate canons of ethics.

The word "canons" is here used in place of "code" so as to clearly distinguish by name matters that are ethical principles from those that are affairs of practice. Many codes of practice, which are established on the grounds of safety, convenience, or law rather than on ethical principles, exist in the lists of the various societies, and particularly in the lists of the A.S.M.E. Thus the distinction in title is needed.

The proposed canons have been formulated in the effort to include only such items as involve rules of right conduct relating to ethical contacts in society that are often enough violated by engineers in their engineering affairs to make it desirable to set them down formally for the information of young engineers and the inspiration of older ones. It has been intended to avoid items that relate strictly to practice which is a matter of custom and may be changed, and also to avoid points which are controlled by statutory law and therefore may be changed, and those which are controlled by the tenets of religion and therefore relate broadly to human life rather than specifically to the engineering profession.

Much urgency has been expressed for reducing the number of the items, but the three national societies which have thus far adopted the canons have not joined in urging the omission of items. The American Institute of Consulting Engineers has suggested a considerable rearrangement of the order of the items and some modification of phraseology. One notable local engineering society, the Engineering Society of Detroit, has already adopted these canons.

With this introduction, each member of the A.S.M.E. can intelligently read, understand, and reflect on the proposed canons, which follow herewith:

PROPOSED CANONS OF ETHICS FOR ENGINEERS[1]

(With Revisions as of November 2, 1942)

FOREWORD

Justice, courtesy, honesty, and sincerity, associated with mutual interest between men, make the foundation of ethics. Ethics should be more than passive observance of a code of "Don'ts" in the life of an engineer. They should be recognized as dynamic principles guiding his conduct and his way of life.

The principles are briefly set forth in what follows:

PROFESSIONAL LIFE AND EMPLOYMENT

(1) The engineer will avoid conduct and practices likely to discredit the honor and dignity of the engineering profession.

(2) He will co-operate in building up the engineering profession by interchanging information and experience with other engineers and students and by contributing to the work of engineering societies, schools, and the scientific and engineering press, without disclosing confidential matter.

(3) He will present clearly the consequences to be expected from the deviations proposed if his engineering judgment is overruled by nontechnical authority in cases where he is responsible for the technical adequacy of engineering work.

(4) He will endeavor to protect the engineering profession and all reputable engineers from misrepresentation and misunderstanding.

(5) He will take care that credit for engineering is attributed to those who, in so far as his knowledge goes, are the real authors of the work.

(6) He will maintain the principle that unduly low compensation for engineering employment tends toward inferior

[1] At the meeting of the Council of E.C.P.D. on October 18, 1942, it was voted that these Canons of Ethics be approved in principle and referred "to the constituent organizations with a statement that they are proposed for adoption and that E.C.P.D. would like to receive from the Boards (1) comments or instructions and (2) specific indications of any items which should be omitted, or others which should be added."

Prepared by a joint committee from national engineering societies (American Institute of Chemical Engineers, American Institute of Consulting Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, The American Society of Mechanical Engineers, The Engineering Institute of Canada, National Council of State Boards of Engineering Examiners, Society for the Promotion of Engineering Education) with sponsorship of Engineers' Council for Professional Development.

and unreliable results and is to the disadvantage of his profession.

(7) He will not advertise his work or merits in a self-laudatory manner or in a way injurious to the dignity of his profession.

RELATIONS WITH OTHER ENGINEERS

(8) The engineer will not intentionally, directly or indirectly, injure the reputation or business of another engineer.

(9) He will not try to supplant another engineer in a particular employment after becoming aware that decision to employ the other has been reached.

(10) He will not compete with another engineer on the basis of charges for work by underbidding through reducing his normal fees after he has been informed of the charges named by the other.

(11) He will not use personally the advantages of a salaried position to compete unfairly with another engineer.

(12) He will not knowingly review the work of another engineer, for the latter's client or employer, without the other engineer's knowledge unless the latter's connection with the work has terminated.

(13) He will not knowingly become associated in responsibility for engineering work with engineers who do not conform to ethical practices.

RELATIONS WITH CLIENTS AND EMPLOYERS

(14) The engineer will endeavor, in so far as it is possible, to secure justice between his client or employer and the contractor when dealing with contracts.

(15) He will act in professional matters for each client or employer as a faithful agent or trustee.

(16) He will not accept compensation, financial or otherwise, from more than one interested party for the same service, or for services pertaining to the same work, without the consent of all interested parties.

(17) He will not, without the full knowledge and consent of his client or employer, have an interest in any business which may bias his judgment regarding engineering work for which he is employed or which he may be called upon to perform, or have an interest in a business which may compete with the business of his client or employer.

(18) He will not be financially interested in the bids as a contractor on competitive work for which he is employed as an engineer unless he has the consent of his client or employer.

(19) He will not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with his client or employer.

(20) He will make his status clearly understood to his client or employer before undertaking an engagement if he may be called upon to decide on the use of inventions, apparatus, or any other thing in which he may have a financial interest.

(21) He will regard it his duty to guard against dangerous elements in apparatus, structures, or plant, or dangerous conditions of operation therein, and upon observing such conditions in work with which he is associated, he will call them to the attention of his client or employer. If dangerous conditions persist with his knowledge, he is not fully relieved of his responsibilities.

(22) He will, when he is a public officer, recognize his limitations and, under such conditions, retain and co-operate with other engineering experts and specialists whenever such co-operation may be serviceable.

RELATIONS WITH THE PUBLIC

(23) The engineer will interest himself in the public welfare and be ready to apply his special knowledge, skill, and training for the benefit of mankind.

(24) He will assist public officials and others in attaining a fair and correct general understanding of engineering matters, extend the public knowledge of engineering, and discourage untrue, unfair, and exaggerated statements regarding engineering.

(25) He will recognize the fact that meetings of engineering societies and the engineering press provide the proper forum for technical discussions and criticisms, and also that clear statements of facts relating to engineering enterprises are often of value to the public when they are prepared for laymen's understanding and released by competent authority through the public press.

(26) He will not issue *ex parte* statements, criticisms, or arguments on matters connected with public policy which are inspired or paid for by private interests unless he indicates on whose behalf he is making the statements.

(27) He will not express publicly an opinion on an engineering subject without being informed as to the facts relating thereto.

(28) He will express no opinion which is not founded on adequate knowledge and honest conviction while he is serving as a witness before a court, commission, or other tribunal.

(29) He will not lend his name to any questionable enterprise or engage in any occupation contrary to law.

(30) He will make provisions for safety of life and health of employees and of the public who may be affected by the work for which he is responsible.

(31) He will carry on his work in a spirit of fairness and loyalty to associates, subordinates, and employees, fidelity to the public needs, and devotion to high ideals of courtesy and personal honor.

A Practical Program for Human Rehabilitation

(*Continued from page 178*)

each returned man in the proper classification either for immediate or for eventual employment.

STEPS IN ORGANIZING A PROGRAM

In conclusion let us briefly summarize the outstanding points of this program:

1 Now is the time to organize; do not wait until the disabled veterans return from the war.

2 A well-organized program in each company is necessary for success. In many organizations, this consists of close co-operation between Medical, Personnel, Training, and Safety Divisions, and supervisors.

3 A survey of jobs is essential.

4 Employers of small groups can participate because of firsthand knowledge of their jobs.

5 The production, safety, and absentee record of the physically handicapped is above average.

6 State compensation laws could be changed to benefit the program.

7 Classification of handicapped individuals should be clarified.

8 "War neurosis" cases will benefit from quick employment, with special attention given to individual cases.

9 We recommend to other communities their sincere consideration of "The Peoria Plan" (a booklet describing this plan is now being prepared).

"The Peoria Plan" for human rehabilitation is a fine humanitarian program which gives to every individual the opportunity to receive his "God-given rights" to care for himself and for his dependents. Above all, it demonstrates the willingness of all who are concerned to contribute their share in making the United States of America the outstanding example of true democracy.

PROCESS CONTROL TERMS

Proposed by Terminology Committee of Industrial Instruments and Regulators Division, A.S.M.E.

THE need for a consistent and usable set of terms applying to industrial process control has been evident for a number of years. Suppliers and users alike frequently find it difficult to discuss the subject, either among themselves or with each other, without floundering for want of a common language. Further, in the writing of specifications for new equipment, and in giving directions for its application, the desirability of having at hand a standard set of terms has become increasingly apparent.

The list of automatic-control terms and definitions which follows is presented for the purpose of inviting suggestions and criticisms. It was prepared by the Terminology Committee of the Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers. This committee was originally organized under the past Committee on Industrial Instruments and Regulators of the Process Industries Division. Its members are N. Belaef, D. P. Eckman, W. B. Heinz, J. B. McMahon, J. C. Peters, Ed S. Smith, H. E. Wheeler, J. I. Yellott, and H. F. Moore, chairman.

A revised list of terms is to be presented for adoption by the division after all interested parties have had an opportunity to study the terms and offer comments. All those interested, regardless of affiliation, are urged to send suggestions and criticisms before June 15, to H. F. Moore, chairman, Terminology Committee, I.I.R.D. of A.S.M.E., P.O. Box 37, Elizabeth, N. J. Reprints of the list will be sent upon request. It is recommended that, in so far as possible, criticisms be accompanied by specific suggested changes.—H. F. Moore.

A revised list of process control terms is to be presented for adoption by the A.S.M.E. Industrial Instruments and Regulators Division after all interested parties have had an opportunity to study the terms and offer comments. All those interested, regardless of affiliation, are urged to send suggestions and criticisms before June 15, to H. F. Moore, chairman, Terminology Committee, I.I.R.D .of A.S.M.E., P.O. Box 37, Elizabeth, N. J. Reprints of the list will be sent upon request. It is recommended that, in so far as possible, criticisms be accompanied by specific suggested changes.

Alphabetical List of Terms

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Automatic controller	1
Automatic control system	2
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Control agent	14
Control point	9
Controlled variable	8
Controlling means	31
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Classified List of Automatic-Control Terms and Definitions

A GENERAL AUTOMATIC-CONTROL TERMS

1 An *Automatic Controller (or Regulator)* is a mechanism which measures the value of a quantity or condition subject to change with time, and operates to maintain within limits this measured value.

2 An *Automatic Control (or Regulation) System* consists of two or more interconnected automatic controllers (or regulators) acting together to maintain within limits a single designated variable.

3 A *Self-Actuated Controller (or Regulator)* is one in which all the energy necessary to operate the final control element is supplied by the measuring element.

4 A *Relay-Operated Controller (or Regulator)* is one in which the motion or force developed by the measuring means is used to operate an amplifying relay, the output from which operates the final control element, either directly or through additional relays.

5 A *Plant* comprises the apparatus in which a variable is to be controlled.

6 A *Process* comprises the collective functions performed in and by a plant or equipment in which a variable is to be controlled.

7 *Process Characteristics* comprise those physical characteristics related to the problem of automatic control. Factors which determine process characteristics include those associated with material being processed and those representing the

effect of automatic controllers applied to the process, other than the particular one under consideration, in addition to those associated with the process proper.

8 A *Controlled Variable* is a quantity or condition which is measured and controlled by an automatic controller.

9 The *Control Point* is that value of a controlled variable which an automatic controller operates to maintain.

10 The *Deviation* is the difference at any instant between the value of the controlled variable and the control point or (e.g. in the case of a proportional-position control) a selected reference value.

11 *Drift* is a sustained deviation. In a corresponding controller, drift results from the predetermined relation between values of the controlled variable and positions of the final control element.

12 *Corrective Action* is a change in the flow of the control agent initiated by the measuring means of an automatic controller.

13 A *Neutral Zone* of an automatic controller is a predetermined range of values of the controlled variable, within which no control action occurs.

14 A *Control Agent* is that process energy or material whose flow is directly varied by a final control element.

15 *Self-Regulation* is that operating characteristic which inherently assists or opposes the establishment of equilibrium. In the latter case the self-regulation is said to be negative.

16 *Stable Control* is control in which the value of the controlled variable is maintained within, or returned within, desirable limits without sustained oscillation.

B TYPES OF AUTOMATIC CONTROLLER ACTION

17 *Two-Position (Open and Shut, On-Off) Controller Action* is that in which a final control element is moved immediately, from one extreme to the other extreme of its stroke, at predetermined values of the variable.

18 *Two-Position Single-Point Controller Action* refers to the particular case of two-position action in which the predetermined values are identical.

19 *Two-Position Differential Gap Controller Action* is two-position action in which a final control element is moved in one direction at a predetermined value of the controlled variable, and subsequently in the other direction only after the value of the variable has crossed a "differential gap" to a second predetermined value.

20 *Corresponding Controller Action* is that in which there is a predetermined relation between values of the controlled variable and positions of a final control element.

21 *Multiposition Controller Action* is that in which there are three or more predetermined positions of a final control element corresponding to definite values of the variable.

22 *Proportional Position Controller Action* is that in which there is a continuous linear relation between the position of a final control element and the value of the controlled variable.

23 *Floating Controller Action* is that in which there is a predetermined relation between values of the controlled variable, and rate of motion of a final control element, with or without a neutral zone.

24 *Single-Speed Floating Controller Action* is that in which there is a single rate of motion of the final control element.

25 *Multispeed Floating Controller Action* is that in which there are two or more speeds of the final control element, each corresponding to a definite range of values of the controlled variable.

26 *Proportional Speed Floating Controller Action* is that in which there is a continuous linear relation between the rate of motion of a final control element and the deviation of the controlled variable.

27 *Derivative Controller Action* is that in which there is a predetermined relation between a derivative function of the controlled variable and the position of a final control element.

28 *Proportional Plus Floating Controller Action* is that in which Proportional Position and Proportional Speed Floating actions are additively combined.

29 *Other Types* representing combinations of types 17–28 may be designated and defined by using suitable combinations of the terms and definitions given.

C ELEMENTS OF AUTOMATIC CONTROLLERS

30 The *Measuring Means* of an automatic controller consists of those elements which are involved in ascertaining and communicating to the controlling means the magnitude of the controlled variable.

31 The *Controlling Means* of an automatic controller consists of those elements which, acting together, produce corrective action based upon the information supplied by the measuring means.

32 The *Final Control Element* is that portion of the controlling means which directly varies a control agent.

33 A *Power Unit* is a mechanism of a relay-operated controller which applies power to move a final control element in response to changes in relay output.

34 A *Relay* is a device which uses an auxiliary source of energy to amplify or convert the motion or force of the measuring means (or a previous relay) into available quantities of energy.

35 *Relay Supply* is the auxiliary energy supplied to a relay.

36 *Relay Output* is that portion of the relay supply which is transmitted to the power unit or to another relay.

D TERMS RELATED TO CONTROLLER ADJUSTMENT

37 The *Proportional Band*, applying to proportional position controller action, is the range of scale values through which the controlled variable must pass in order that the final control element be moved through its entire range. A uniform scale of range 0–100 per cent is commonly assumed for purposes of controller calibration.

38 The *Floating Speed*, applying to floating controller action, is the rate of movement of a final control element corresponding to a specified deviation. It is conveniently expressed in per cent of full range of movement per unit of time.

39 The *Floating Rate*, applying to proportional plus floating controller action, is expressed in units of the number of times per unit time that the effect of proportional position action is reproduced by proportional speed floating action.

40 The *Floating Time*, applying to proportional plus floating controller action, is the reciprocal of floating rate.

E BASIC CHARACTERISTICS AND ELEMENTS

41 *Capacitance* is a measure of ability to contain. Electrical capacitance is expressed in units of change per unit of potential difference, Thermal Capacitance in thermal units per unit of temperature difference, Hydraulic Capacitance in volume units per unit change in head, etc.

42 A *Capacitor* is an element of a plant or of a controller which has as its most significant characteristic for automatic-control purposes the ability to contain.

43 *Resistance* is a measure of ability to restrict flow. Electrical Resistance (assuming a steady direct current) is expressed in units of potential difference required to produce unit current, Thermal Resistance as temperature difference required to produce unit rate of flow of heat, Hydraulic Resistance as difference in head required to produce unit rate of flow of liquid, etc.

44 A *Resistor* is an element of a plant or of a controller which has as its most significant characteristic for automatic-control purposes the ability to restrict flow.

45 *Dead Time* is any definite delay period between the time when a change occurs in a control agent and the time when that change affects the controlled variable at the point of measurement.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

National Fire Codes for Flammable Liquids, Gases, Chemicals, and Explosives

National Fire Codes for Flammable Liquids, Gases, Chemicals, and Explosives. Compiled by Robert S. Moulton, Technical Secretary, National Fire Protection Association, Boston, Mass. Published by the Association, 1943. Cloth, 6 × 9 in., 502 pp., illus., $3.

THE 1943 revised edition of the National Fire Codes for Flammable Liquids, Gases, Chemicals, and Explosives is now available. This handy publication replaces the 1938 edition and brings up to date this valuable collection of the many standards and codes dealing with the fire hazards associated with the transportation, storage, and use of flammable liquids, gases, chemicals, and explosives. The number and diversity of these standards has now become so great that it is difficult for the average user who is interested in a wide variety of subjects to keep track of all the standards when separately published in small pamphlet form.

This volume is published by the National Fire Protection Association and appears at a most propitious time as an authoritative guide for preventing fires. This new volume is divided into nine parts as follows: Flammable liquid storage and handling; oil and gasoline burning equipment; liquefied petroleum gases; utilization of flammable liquids; gases; refrigeration and fumigation; explosive and nitrocellulose materials; tables of properties—hazardous chemicals, flammable liquids; flash-point tests.

Part 8 consisting of Tables of Properties of the Common Hazardous Chemicals, twenty-eight pages, and the Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, forty-eight pages, should have a wide interest and use. The column headings of the first table are: (1) Name; (2) usual shipping container; (3) fire hazard; (4) life hazard; (5) storage; (6) fire-fighting phases; (7) remarks. Those of the second table are: (1) Flash point, deg F, ref; (2) ignition temp, deg F, ref; (3) explosive limits, per cent by volume, lower, upper, ref; (4) specific gravity (water = 1); (5) vapor density, air = 1; (6) boiling point, deg F; (7) underwriters' laboratories class; (8) factory mutual's recommended extinguishing agent.

The several codes are in the form of suggested ordinances, standards or recommended good-practice requirements. They are universally recognized and used as the authoritative guides to the best practice. Irrespective of their form, the codes are purely advisory as far as the N.F.P.A. is concerned. They are, however, widely used as a basis of law, or by administrative authorities in the exercise of their discretionary power, as well as by property owners as a guide to good practice and for insurance purposes. In preparing all standards the aim of the N.F.P.A. committees has been to specify measures that will provide reasonable fire safety without prohibitive expense, or undue inconvenience.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

Books Received in Library

A.S.T.M. Standards on Paper and Paper Products, prepared by A.S.T.M. Committee D-6 on Paper and Paper Products: Methods of Testing, Specifications. American Society for Testing Materials, Philadelphia 2, Pa. November, 1943. Paper, 6 × 9 in., 138 pp., illus., diagrams, charts, tables, $1.35 ($1 to A.S.T.M. members).

A.S.T.M. Standards on Plastics, sponsored by A.S.T.M. Committee D-20 on Plastics: Specifications, Methods of Testing, Nomenclature, Definitions, October, 1943. Paper, 6 × 9 in., 431 pp., illus., diagrams, charts, tables, $2 ($1.50 to A.S.T.M. members).

A.S.T.M. Standards on Textile Materials (with related information), prepared by A.S.T.M. Committee D-13 on Textile Materials: Specifications, Tolerances, Methods of Testing, Definitions and Terms, October, 1943. Paper, 6 × 9 in., 457 pp., illus., diagrams, charts, tables, $2.25 ($1.50 to A.S.T.M. members). These three publications are intended primarily to present in convenient form the A.S.T.M. standard and tentative standard methods of test and specifications pertaining to their respective subjects. Glossaries and descriptive nomenclature are included for the plastics and textile materials, and in the textile-materials volume abstracts are printed of three papers presented at a recent meeting.

Double-Speed Synchronous Generator. University of California Publications in Engineering, vol. 4, no. 3, pp. 27–36. By A. Tilles. University of California Press, Berkeley and Los Angeles, Calif., 1943. Paper, 8½ × 11 in., diagrams, charts, $0.25. A method is presented of operating a machine as a synchronous machine at twice its ordinary synchronous speed. The basic operating characteristics are given, and the behavior of the machine as a part of a system and in commercial application is indicated in a general way.

Handbook of Tabular Presentation, How to Design and Edit Statistical Tables, a Style Manual and Case Book. By R. O. Hall. Ronald Press Co., New York, N. Y., 1943. Cloth, 8½ × 11 in., 112 pp., charts, tables, $3.50. The designing and editing of statistical tables are discussed on the basis of broad practical experience in this book, which will be found useful by all who have to present matter in tabular form. The principles which are presented are illustrated by a collection of tables.

Hydraulics, Parts 1–4. By H. P. Hammond. International Textbook Co., Scranton, Pa., 1942. Each part paged separately. Fabricoid, 5 × 7¾ in., illus., diagrams, charts, tables, $3. Part 1 of this elementary textbook deals with hydrostatics. Part 2 discusses the discharge of orifices, tubes, and weirs, and covers the subject of nozzles. Flow through pipes, including the determination of power delivered by or to water flowing in a pipe, occupies part 3. Part 4 takes up flow in open channels and covers stream gaging. Numerical examples for practice accompany the various subdivisions of the parts.

Industrial Safety. By T. O. Armstrong, R. P. Blake, J. J. Bloomfield, C. B. Boulet, M. A. Gimbel, S. W. Homan, W. D. Keefer, and R. T. Page; edited by R. P. Blake; foreword by H. T. Heald. Prentice-Hall, Inc., New York, N. Y., 1943. Cloth, 6 × 9½ in., 435 pp., illus., diagrams, tables, $5. A series of chapters by authorities in the field provides a handbook useful to all industries. Subjects discussed include the history of industrial safety, causes of industrial accidents, accident prevention, inspection, safeguarding machinery, safety training and education, accident hazards, reports, and records. Fire prevention, first aid, and personal protective equipment are also covered in separate chapters.

Manual of Firemanship, Part I. Great Britain, Home Office (Fire Service Depart-

ment). His Majesty's Stationery Office, London, England, 1943. Paper, $5^1/_2 \times 8^1/_2$ in., 250 pp., illus., diagrams, tables, 2s 6d. (Obtainable from British Information Services, New York, N. Y., $0.75.) This book is the first section of a proposed seven-part work which is intended to be a comprehensive text-book and reference work for fire fighters. The present installment discusses the theory of fire fighting and the equipment. The theory of combustion, methods of extinguishing fires, hose, hose fittings, ladders, ropes, hand pumps, chemical extinguishers and foams, apparatus for breathing and resuscitation are discussed. Much information of a practical nature is given.

MARINE ELECTRIC POWER. By Q. B. Newman. Second edition. Simmons-Boardman Publishing Corp., New York, N. Y., 1943. Cloth, $4^1/_2 \times 8$ in., 238 pp., diagrams, charts, tables, $2.50. This book provides a very clear explanation of the fundamental principles of electrical engineering as applied to marine electrical power. Mathematics is practically absent, and only the slightest knowledge of physics is required. The new edition has been considerably enlarged by six chapters on the practical application of the principles.

MARINE ENGINE AND FIRE ROOM GUIDE. By R. H. Jacobs and E. L. Cady. Cornell Maritime Press, New York, N. Y., 1943. Cloth, $5 \times 7^1/_2$ in., 740 pp., illus., diagrams, charts, tables, $3.50. This is a handbook of information for wipers, firemen, and water-tenders on ships, which covers in a practical way the theory of the machinery in their care and the operation and maintenance of it.

MAXIMUM UTILIZATION OF EMPLOYED MAN-POWER, a Check List of Company Practice. (Research Report Series No. 68.) Princeton University, Industrial Relations Section, Princeton, New Jersey, 1943. Paper, $6 \times 9^1/_2$ in. 46 pp., $1. This publication constitutes an outline listing a wide range of symptoms or ailments which are likely to accompany or cause underutilization of employed labor. Most of the subheadings, however, indicate positive steps, drawn from widespread company experience, which have proved successful remedies. A detailed bibliography is appended to the report.

MECHANICAL HANDLING YEAR BOOK AND MANUAL 1943. Edited by H. Pynegar, Paul Elek (Publishers), Ltd., Africa House, Kingsway, London, England, W.C.2, 1943. Cloth, $5^1/_2 \times 9$ in., 399 pp., illus., diagrams, charts, tables, 30s net. This British handbook deals with underground machine mining, with screening, conveying, and elevating, and with industrial trucks and cranes. The equipment of many manufacturers is described, as well as numerous installations.

MECHANICS OF MATERIALS. By S. G. George and E. W. Rettger, revised by E. V. Howell. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 491 pp., diagrams, charts, tables, $3.75. A simple, complete account of the essentials of the subject is provided, suitable for use as a college text, but containing more material than is usually covered in an elementary course. In this edition the sequence of chapters has been altered, rivet and column specifications have been revised, and an article added on the graphical solution of combined stresses.

METAL FORMING by FLEXIBLE TOOLS. By C. J. Frey and S. S. Kogut. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1943. Cloth, $6 \times 9^1/_2$ in., 193 pp., illus., diagrams, charts, tables, $3. The characteristics of the flexible tool, developed and mainly applied in the aircraft industry, are low first cost and rapidity of manufacture, to meet the frequent changes in design necessitated by war, and the ability to adhere to sheet-metal tolerances so as to permit interchangeability. The answer to the need for flexible tooling has been found in the rubber press, the drop hammer, the power brake, the stretch press, and the Anderson method of forming by drawing, all described in detail in this book.

METALS AND ALLOYS DATA BOOK. By S. L. Hoyt. Reinhold Publishing Corporation, New York, N. Y., 1943. Cloth, $7 \times 10^1/_2$ in., 334 pp., illus., diagrams, charts, tables, $4.75. Mr. Hoyt has performed a task of great value, and the result will be most useful to metallurgists and engineers. It contains, in compact, usable form, carefully selected values for the physical and engineering properties of the metals and alloys of commercial importance. The wrought, cast, and stainless steels, cast irons, heat-resistant and corrosion-resistant casting alloys and nonferrous alloys are covered in detail. The data are chiefly presented in tables, with brief comment.

ON YOUR OWN, How to Take Care of Yourself in Wild Country, a Manual for Field and Service Men. By S. A. Graham and E. C. O'Roke. University of Minnesota Press, Minneapolis, Minn., 1943. Cloth, 5×8 in., 149 pp., diagrams, tables, $2. This little manual, prepared by two experienced foresters, is intended to assist field workers in avoiding trouble in wild country. Suggestions on meeting extremes of temperature, on preventing and treating minor injuries and infection, on avoiding quicksand, quagmire, and water hazards, on food, on catching wild animals, on protection from poisonous plants and from insects, on dangerous animals, and on parasites are provided. The book should be most useful to travelers.

OPTICAL CRYSTALLOGRAPHY. By E. E. Wahlstrom. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England. Cloth, $5^1/_2 \times 8^1/_2$ in., 206 pp., illus., diagrams, charts, tables, $3. It is the purpose of this textbook to review the principles of optical crystallographic theory. Practical applications are treated briefly, as the emphasis is placed on the thorough presentation of fundamental concepts. Some space is given to a description of the techniques for the measurement of refractive indices. The text is profusely illustrated, a particularly helpful feature in a book on this subject.

(The) PHYSICS OF METALS. By F. Seitz. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Fabrikoid, $5^1/_2 \times 8^1/_2$ in., 330 pp., diagrams, charts, tables, $4. This work is based on an evening lecture course given to practicing metallurgists with a limited knowledge of physics. The treatment is entirely nonmathematical. The developments of recent years are discussed, including the structure of metals, the factors that determine the stability of alloys, the theory of plasticity in metals, diffusion in metals, the theory of iron-carbon alloys, and the electron theory of solids and its applications to cohesion, magnetism and conductivity.

PRODUCTION CONTROL. By A. S. Knowles and R. D. Thomson. Macmillan Co., New York, N. Y., 1943. Cloth, $5^1/_2 \times 9$ in., 271 pp., illus., diagrams, charts, tables, $2.50. Part I of this book deals with the problems which arise in establishing and administering operating controls, covering storeskeeping, development and engineering of the manufacturing processes, and planning. Part II deals with the control of those elements of total costs of manufacturing about which the manager needs particular knowledge, but which require no specialized accounting background. The text is a reproduction of two sections of a larger volume on industrial management.

QUESTIONS AND ANSWERS FOR MARINE ENGINEERS. BOOK IV—APPLICATIONS OF STEAM AND HEAT IN PRODUCING POWER. Compiled by Capt. H. C. Dinger. Marine Engineering and Shipping Review, Simmons-Boardman Publishing Corp., New York, N. Y., 1943. Paper, 5×8 in., 83 pp., charts, tables, $1. The fourth of these booklets dealing with problems that confront marine engineers deals with questions relating to evaporation, condensation, and heat engine-systems.

RAILWAY FUEL AND TRAVELING ENGINEERS' ASSOCIATION. Sixth Annual Proceedings, 1942. Railway Fuel and Traveling Engineers' Association, 327 So. La Salle St., Chicago, Ill. Fabrikoid, $6 \times 9^1/_2$ in., 198 pp., tables, $3. The papers presented to the Association and included in this volume discuss locomotive fuel economy, oil firing practice, gas-turbine locomotives, and similar topics. Reports of Committees are also included.

ROEMER AND THE FIRST DETERMINATION OF THE VELOCITY OF LIGHT. By I. B. Cohen. The Burndy Library, Inc., 107 Eastern Boulevard, New York, N. Y., 1942. Paper, 6×9 in., 63 pp., illus., diagrams, tables, $0.50. This study originally appeared in volume 31 of ISIS but owing to the loss of the original publication when Belgium was invaded is now republished with some additions and corrections. The study discusses views previous to Roemer, the immediate background of Roemer's determination, and the reception given his work. Facsimiles of his announcement and of the first account in English are included.

SLIDE RULE SIMPLIFIED. By C. O. Harris. American Technical Society, Chicago, Ill., 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 250 pp., diagrams, tables, $2.50; with slide rule, $3.50. The practical manipulation of the slide rule is explained in detail. The first eight chapters cover the relatively simple straight arithmetical operations for the beginner. Succeeding chapters deal with the handling of trigonometrical relations and other more complex operations. The logarithmic basis of the functioning of the slide rule is explained for those who are interested.

SMOKE STREAMS, VISUALIZED AIR FLOW. By C. T. Ludington, preface by E. Warner. Coward-McCann, Inc., New York, N. Y., 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 144 pp., illus., diagrams, charts, $2.75. The fundamentals of aerodynamics are here presented in simple language and illustrated by excellent photographs taken in the Griswold smoke tunnel. Lift, drag, high-lift devices, downwash, and tip losses are explained and shown graphically. The book will interest not only pilots in training, but also young model-makers.

(The) STEAM BOILER YEARBOOK AND MANUAL. Second edition. Edited by S. D. Scorer, foreword by R. J. Sarjant. Paul Elek (Publishers) Ltd., Africa House, Kingsway, London, England, W.C.2, 1943. Cloth, $5^1/_2 \times 9$ in., 522 pp., illus., diagrams, charts, tables, 30s 10d or abroad 31s 6d. This book aims to provide descriptions of the best that is available in steam boilers and their equipment, together with a résumé of developments in design and operation during 1942. Chapters are devoted to various boiler types, feedwater pumps, and stokers, in which good practices are reviewed and illustrated by descriptions of British products. A second section consists of lengthy abstracts of articles from periodicals of 1942, upon fuel and fuel economy, steam economy and operating.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of January 7, 1944, subsequently approved by the A.S.M.E. Council.

CASE No. 997

(*Special Ruling*)

Add the following to the reply:

Circular spherically dished heads convex to pressure with bolting flanges shall be designed by the formulas given in Fig. 40, except that the head thickness shall be $1^2/_3$ times the value obtained by the formula. There need be no increase in the flange thickness except as would be required in detail *C*.

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph number to identify their location in the various sections of the code and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-102. Revise first section to read:

IN APPLYING THE RULES IN PAR. P-180, A WELDED JOINT EFFICIENCY OF 95 PER CENT MAY BE USED, PROVIDED THE WELD REINFORCEMENT IS REMOVED SUBSTANTIALLY FLUSH WITH THE SURFACE OF THE PLATE. OTHERWISE A JOINT EFFICIENCY NOT TO EXCEED 90 PER CENT SHALL BE USED. [The joint efficiency E to be used in applying the rules in Par. P-180 shall be taken as 90 per cent.]

PAR. P-104(*d*). Revise first section to read:

In all cases where plates of unequal thicknesses are abutted, the edge of the thicker plate shall be reduced BY A TAPER OF NOT LESS THAN 4 TO 1, AS SHOWN IN FIG. P-$5^1/_2$ so that it is of approximately the same thickness as the other plate.

PAR. P-108(*a*). Add the following to the last sentence:

to a temperature not exceeding 600 F.

PAR. P-112(*c*). Add the following as the fourth section of the proposed revision as published in May, 1943, MECHANICAL ENGINEERING:

When the process does not include a backing ring, the welding operator shall be qualified without the use of a backing ring.

PAR. P-112(*d*). Revise to read:

(*d*) Pipe connections NOT EXCEEDING [up to] $^1/_2$ in. pipe size may be welded to pipe under the provisions of this paragraph without Code inspection.

PAR. P-292. Revise to read:

P-292 EACH WATER GAGE GLASS SHALL BE PROVIDED WITH TOP AND BOTTOM SHUTOFF VALVES. Automatic shutoff valves, [on water gages] if permitted to be used, shall conform to the requirements given in Par. A-18 of the Appendix.

PAR. A-19. Revise to read:

A-19 (*a*) Fire-actuated fusible plugs, if used, shall be filled with a composition suitable for the pressures and temperatures with which the plugs will be in contact.

(*b*) The softening temperature of the fusible metal used shall be stamped on the metal and the plug shall not be used at a saturated steam temperature exceeding the marking.

(*c*) Casings of fusible plugs shall be made of a material that is corrosion-resistant when subjected to the boiler water conditions.

(*d*) The shape and dimensions of the inte-

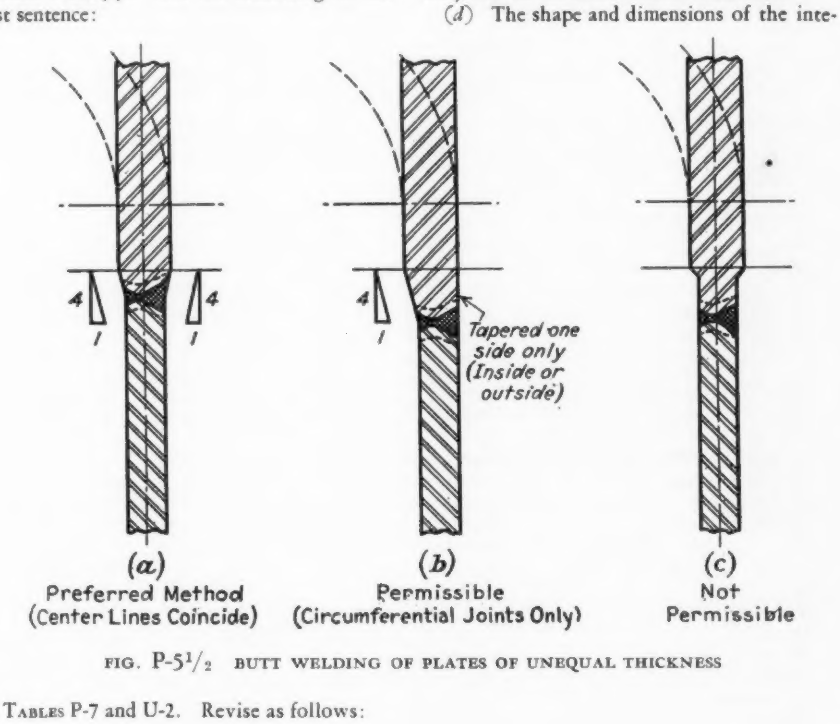


FIG. P-$5^1/_2$ BUTT WELDING OF PLATES OF UNEQUAL THICKNESS

TABLES P-7 and U-2. Revise as follows:

Spec. no.	Grade	Spec. min tens.	650	700	750	800	850	900	950	1000
S-53	B	48,000	9600	9300	8750	7250	5900	4400	2600	1350
S-53	A	52,000	10,400	9900	9200	7700	6100	4400	2600	1350

TABLE Q-5. Add the following:

Spec. no.	Grade	Classification
SA-214	..	"P" Number 1–"O" Number 1
SA-226	..	"P" Number 1–"O" Number 1
S-65 (A 250)	..	"P" Number 4–"O" Number 1
S-64 (A 249)	T 8	"P" Number 8–"O" Number 2
S-64 (A 249)	T 18	"P" Number 9–"O" Number 2
S-64 (A 249)	T 20	"P" Number 10–"O" Number 2
SA-176	2	"P" Number 7–"O" Number 2

TABLE U-3 MAXIMUM ALLOWABLE DESIGN STRESSES FOR NONFERROUS MATERIALS, POUNDS PER SQUARE INCH

Material and spec. no.	Grade, type, or name	Condition	Notes	Spec. min tens.	For metal temperatures not exceeding deg F: Subzero to 150	250	300	350	400*	450	500	600	700	800
ALUMINUM														
Plate, sheet, or strip														
SB-178	Aluminum	Annealed	...	11000	2240	1680	1440	1280	1120	...	...	...	...	...
SB-178	Aluminum	As rolled	...	13000	2640	2080	1920	1600	1200	...	...	...	...	...
SB-178	Aluminum	1/4 Hard	...	14000	2800	2240	2000	1680	1200	...	...	...	...	...
ALUMINUM ALLOYS														
Plate, sheet, or strip														
SB-126	Alum. Mang.	Annealed	...	14000	2800	2400	2100	1800	1600	...	...	...	...	...
SB-126	Alum. Mang.	As rolled	...	17000	3400	3000	2700	2400	2200	...	...	...	...	...
SB-126	Alum. Mang.	1/4 Hard	...	17000	3400	3000	2700	2400	2200	...	...	...	...	...
COPPER														
Bar, rod, or shapes														
SB-12	...	Annealed	...	30000	6000	5000	4750	4500	3000	...	...	...	...	...
Pipe or tube														
SB-13	...	Annealed	(9)	30000	6000	5000	4750	4500	3000	...	...	...	...	...
SB-42	...	Annealed	(9)	30000	6000	5000	4750	4500	3000	...	...	...	...	...
SB-42	...	Light drawn	(9)	36000	7200	6000	5000	4500	3000	...	...	...	...	...
SB-42	...	Hard drawn	(3), (9)	50000	10000	9000	7000	5000	3000	*	...	...	...	...
SB-75	...	Annealed	...	30000	6000	5000	4750	4500	3000	...	...	...	...	...
SB-75	...	Light drawn	...	36000	7200	6000	5000	4500	3000	...	...	...	...	...
SB-75	...	Hard drawn	(3)	50000	10000	9000	7000	5000	3000	*	...	...	...	...
SB-111	...	Light drawn	...	36000	7200	6000	5000	4500	3000	...	...	...	...	...
SB-111	...	Hard drawn	...	50000	10000	9000	7000	5000	3000	*	...	...	...	...
Bar, rod or shapes														
SB-11	...	Annealed	...	30000	6000	5000	4750	4500	3000	...	...	...	...	...
COPPER ALLOYS														
Plate, sheet, or strip														
SB-98	Copper-Silicon													
SB-98	A, C, D	Soft	(4), (6)	52000	10400	10000	10000	5000	...	...	...	...	...	...
SB-98	A, C, D	1/2 Hard	(4)	70000	14000	14000	14000	10000	...	...	...	...	...	...
SB-98	A, C, D	Hard	(4), (7)	85000	17000	17000	17000	10000	...	...	...	...	...	...
SB-98	A, B	Soft	(4)	40000	8000	8000	7000	5000	...	...	...	...	...	...
SB-98	A, B	1/2 hard	(4)	55000	11000	11000	10000	8000	...	...	...	...	...	...
SB-98	A, B	Hard	(4)	65000	13000	13000	12000	8000	...	...	...	...	...	...
SB-98	A, B	Ex hard	(4), (10)	75000	15000	15000	12000	8000	...	...	...	...	...	...
SB-98	A, B	Hot temper	(4), (11)	85000	17000	17000	12000	8000	...	...	...	...	...	...
Castings														
SB-61	...	...	(5)	34000	6800	6800	6500	6000	5500	5000	4000	3000	...	...
SB-62	...	...	(5)	30000	6000	5500	5000	4500	3500	...	...	...	...	...
Pipe or Tube														
SB-43	Muntz	Annealed	(9)	50000	10000	9000	7000	2000	1500	...	...	...	...	...
SB-43	High brass	Annealed	(9)	45000	9000	9000	9000	6000	3000	1500	800	...	...	...
SB-43	Admiralty	Annealed	(9)	45000	9000	9000	9000	6000	5500	4500	800	...	...	...
SB-43	Red Brass	Annealed	(9)	40000	8000	8000	7000	6000	3000	1500	800	...	...	...
SB-111	Alum. Brass	Annealed	(9)	45000	9000	9000	9000	6000	3000	1500	800	...	...	...
SB-111	Alum. Bronze	...	(9)	50000	10000	9000	9000	6500	3000	1500	800	...	...	...
SB-111	Muntz	Annealed	(9)	50000	10000	9000	7000	2000	1500	...	...	...	...	...
SB-111	Admiralty	Annealed	(9)	45000	9000	9000	9000	6000	5500	4500	800	...	...	...
SB-111	Red Brass	Annealed	(9)	40000	8000	8000	7000	6000	3000	1500	800	...	...	...
SB-111	Copper Ni. 70-30	Annealed	(9)	55000	11000	11000	11000	11000	11000	11000	10000	10000	9000	...
SB-111	Copper Ni. 80-20	Annealed	(9)	50000	10000	10000	10000	10000	10000	10000	9000	9000	8000	...
Plate or Sheet														
SB-96	Copper Si. A, C	Annealed	(4)	50000	10000	10000	10000	5000	...	...	...	...	...	...
SB-171	Alum. Bronze	Annealed	...	90000	18000	10000	...	...	...	...	...	...	...	...
SB-171	Naval Brass	Annealed	...	50000	10000	10000	10000	6000	3000	...	...	...	...	...
SB-171	Muntz	Annealed	...	50000	10000	9000	7000	2000	1500	...	...	...	...	...
SB-171	Admiralty	Annealed	...	45000	9000	9000	9000	6000	5500	4500	800	...	...	...
SB-171	Copper Ni. 70-30	Annealed	...	50000	10000	10000	10000	10000	10000	10000	9500	9000	8500	...
NICKEL														
Bar, Rod, or Shapes														
SB-160	...	Annealed	...	60000	12000	12000	12000	12000	12000	12000	12000	...	...	...
SB-160	...	Hot rolled	(8)	65000	13000	13000	13000	13000	13000	13000	13000	...	...	...
SB-160	...	Cold drawn	(3)	85000	17000	17000	17000	17000	17000	17000	17000	...	...	...
Pipe or Tube														
SB-161	...	Annealed	...	60000	12000	12000	12000	12000	12000	12000	12000	...	...	...
SB-161	...	As drawn	(1)	80000	16000	16000	16000	16000	16000	16000	16000	...	...	...
SB-163	...	Annealed	...	60000	12000	12000	12000	12000	12000	12000	12000	...	...	...
SB-163	...	As drawn	(1)	65000	13000	13000	13000	13000	13000	13000	13000	...	...	...
Plate, Sheet, or Strip														
SB-162	...	Annealed	...	60000	12000	12000	12000	12000	12000	12000	12000	...	...	...
SB-162	...	As rolled	(2)	70000	14000	14000	14000	14000	14000	14000	14000	...	...	...
SB-162	...	Hard	...	90000	18000	18000	18000	18000	18000	18000	18000	...	...	...
NICKEL ALLOYS														
Bars, Rods, or Shapes														
SB-164	Ni. Copper A & B	Annealed	...	70000	14000	14000	14000	14000	14000	14000	14000	14000	14000	...
SB-164	Ni. Copper A	Hot rolled	...	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	...
SB-164	Ni. Copper B	Hot rolled	...	75000	15000	15000	15000	15000	15000	15000	15000	15000	15000	...
SB-164	Ni. Copper A	Cold drawn	...	85000	17000	17000	17000	17000	17000	17000	17000	17000	17000	...
SB-164	Ni. Copper B	Cold drawn	...	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	...
SB-166	Ni. Chrome Iron	Annealed	...	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
SB-166	Ni. Chrome Iron	Hot rolled	...	85000	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000
SB-166	Ni. Chrome Iron	Cold Drawn	...	105000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000

TABLE U-3 MAXIMUM ALLOWABLE DESIGN STRESSES FOR NONFERROUS MATERIALS, POUNDS PER SQUARE INCH (*Continued*)

Material and spec. no.	Grade, type, or name	Condition	Notes	Spec. min tens.	For metal temperatures not exceeding deg F: Subzero to 150	250	300	350	400*	450	500	600	700	800
Pipe or Tube														
SB-163	Nickel-Copper	Annealed	...	65000	13000	13000	13000	13000	13000	13000	13000	13000	13000	...
SB-163	Nickel-Copper	As drawn	(1)	60000	16000	16000	16000	16000	16000	16000	16000	16000	16000	...
SB-165	Nickel-Copper	Annealed	...	65000	13000	13000	13000	13000	13000	13000	13000	13000	13000	...
SB-165	Nickel-Copper	As drawn	...	90000	18000	18000	18000	18000	18000	18000	18000	18000	18000	...
SB-167	Ni. Chrome Iron	Annealed	...	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
SB-167	Ni Chrome Iron	Annealed	...	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
SB-167	Ni. Chrome Iron	As drawn	...	120000	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Plate, Sheet, or Strip														
SB-127	Nickel-Copper	Annealed	...	70000	14000	14000	14000	14000	14000	14000	14000	14000	14000	...
SB-127	Nickel-Copper	1/4 Hard	...	78000	15600	15600	15600	15600	15600	15600	15600	15600	15600	...
SB-127	Nickel-Copper	Hard	...	100000	20000	20000	20000	20000	20000	20000	20000	20000	20000	...
SB-127	Nickel-Copper	As rolled	(2)	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	...
SB-168	Ni. Chrome Iron	Annealed	...	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
SB-168	Ni. Chrome Iron	As rolled	(2)	80000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
SB-168	Ni. Chrome Iron	Hard	...	125000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000

NOTES ON TABLE U-3:

1 As drawn, stressed equalized "condenser tubes."
2 Hot rolled, as rolled.
3 Round, diameter not over 4 in.
4 There is doubt concerning the suitability of this material when exposed to certain media, and/or high temperatures, particularly steam above 212 F. The user should satisfy himself that it is satisfactory for the service for which it is to be used.
5 In the absence of evidence that the casting is of high quality throughout, values not in excess of 80 per cent of those given in the table shall be used. This is not intended to apply to valves and fittings made to recognized standards.
6 Types "*A*" and "*C*," for hot headed bolts only.
7 Types "*A*," "*C*," and "*D*" for machined bolts up to and including 1 1/2 in. diameter.
8 Also cold hexagon squares and flats.
9 "Minimum tensile strength" not given in specification.
10 For cold headed bolts over 1/2 in. to 1 1/2 in., inclusive.
11 For cold headed bolts up to 1/2 in.
* For steam at 250 psi (406 F) the values given may be used.

tior of fusible plugs shall be such as to positively retain the fusible metal until melted and avoid leakage between the fusible metal and the casing.

(*e*) Fusible plugs shall be tested to demonstrate that they are suitable for the conditions under which they will be used.

(*f*) Fusible plugs shall be renewed at intervals of sufficient frequency to avoid becoming coming inoperative from any cause.

PAR. A-20. Revise to read:

A-20 (*a*) Waterside plugs are fusible plugs which are inserted from the water side of the plate, flue, or tube to which they are attached.

Fireside plugs are fusible plugs which are inserted from the fire side of the plate, flue, or tube to which they are attached.

(*b*) A fusible plug shall be of such length that when installed it shall project at least 3/4 in. on the water side of the plate, flue, or tube and shall extend through the plate, flue, or tube on the fire side as little as possible but not more than 1 in.

(*c*) If a fire-actuated fusible plug is inserted in a tube, the tube wall shall be of a thickness to give four full threads but of a thickness not less than 0.22 in.

(*d*) Fusible plugs which comply with the requirements of the Marine Engineering Regulations and Material Specifications of the United States Coast Guard will meet the intent of the Code for fusible metal having a melting point of 450 F.

FIG. A-10. To be deleted.

PAR. A-21. Revise as follows:

(*c*) Substitute "boilers having water-tube elements and crown sheets" for "Star water-tube boilers."

(*d*) Insert "(standard type)" after "in vertical fire-tube boilers."

(*e*) Delete.

(*f*) Revise "in vertical submerged-tube boilers" to read "in vertical fire-tube boilers (submerged-tube type)."

(*g*) Revise first part to read: In water-tube boilers WITH STRAIGHT TUBES, BOX, OR SECTIONAL HEADERS AND LONGITUDINAL OR CROSS-horizontal drums—in the WATER AND STEAM [upper] drum, etc."

(*h*) Delete.

(*i*) Revise "in Stirling boilers, superheater type" to read: "in water-tube boilers of the bent-tube type—in the front water and steam drum, not less, etc."

(*j*), (*k*), (*l*), (*m*), (*n*) Delete.

(*o*) Delete the word "Wickes."

(*r*) Revise "in economic-type boilers" to read: "in fire-tube boilers of the refractory-lined firebox type."

(*s*) Delete.

TABLE P-6. This table will be revised to make it identical with the proposed revision of Table U-3, except that the additional stresses for nickel and nickel alloys, and the reference to Specifications S-36, S-37, S-39, S-47, and S-54 will be omitted.

Specification S-4. This specification will be deleted and replaced by A.S.T.M. Specifications A 266-43T for Carbon-Steel Seamless Drum Forgings.

Specification S-38. This specification will be deleted and replaced by A.S.T.M. Specifications B 178-43T for Aluminum Sheet and Plate for Use in Welded Pressure Vessels.

Specifications B 160 to B1 68, Inclusive. The following A.S.T.M. Specifications will be added to the Code:

Nickel Rods and Bars (B 160-41T)
Nickel Cold-Drawn Pipe and Tubing (B 161-41T)
Nickel Plate, Sheet, and Strip (B 162-41T)
Nickel, Nickel-Copper Alloy, and Nickel-Chromium-Iron Alloy Seamless Condenser Tubes and Ferrule Stock (B 163-41T)
Nickel-Copper Alloy Rods and Bars (B 164-41T)
Nickel-Copper Alloy Cold-Drawn Pipe and Tubing (B 165-41T)
Nickel-Chromium-Iron Alloy Rods and Bars (B166-41T)
Nickel-Chromium-Iron Alloy Cold-Drawn Pipe and Tubing (B167-41T)
Nickel-Chromium-Iron Alloy Plate, Sheet, and Strip (B168-41T)

PARS. H-61 and H-114. Revise to read as follows:

H-61 (H-114) *Water Gage Glasses.* Each steam boiler shall have one or more water gage glasses ATTACHED TO THE WATER COLUMN OR BOILER BY MEANS OF VALVED FITTINGS, with the lower fitting provided with a valve or pet cock to facilitate cleaning. GAGE GLASS REPLACEMENT SHALL BE POSSIBLE UNDER PRESSURE.

(Transparent material other than glass may be used for the water gage provided that material has proved suitable for the pressure, temperature, and corrosive conditions met with in service.)

PAR. U-68. Revise second section to read:

IN APPLYING THE RULES IN PAR. U-20, A WELDED JOINT EFFICIENCY OF 95 PER CENT MAY BE USED, PROVIDED THE WELD REINFORCEMENT IS REMOVED SUBSTANTIALLY FLUSH WITH THE SURFACE OF THE PLATE. OTHERWISE A JOINT EFFICIENCY NOT TO EXCEED 90 PER CENT SHALL BE USED. [The joint efficiency E to be used in applying the rules in Par. P-180 shall be taken as 90 per cent.]

PAR. U-72(*e*). Revise to read:

(*e*) In all cases where plates of unequal thicknesses are abutted, the edge of the thicker plate shall be reduced BY A TAPER OF NOT LESS THAN 4 TO 1, AS SHOWN IN FIG. U-15 1/2 (same as Fig. P-5 1/2) SO THAT IT IS approximately the same thickness as the other plate.

In longitudinal shell joints the middle lines of the plate thicknesses shall be in alignment, within the fabricating tolerances specified in (*d*) above.

PAR. U-76(*c*). Add the following to the last sentence:

to a temperature not exceeding 600 F.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Three-Day Technical Program at A.S.M.E. Spring Meeting Covers Wide Range of Subjects

Tutwiler Hotel, Birmingham, Ala., to Be Headquarters for Convention Scheduled for April 3–5, 1944

THE technical program of the 1944 Spring Meeting of The American Society of Mechanical Engineers, to be held at Birmingham, Ala., April 3–5, with headquarters at the Tutwiler Hotel, while not entirely completed at the date of going to press, is designed to provide papers of interest and value in furthering the war effort and promises a record attendance of engineers. As in all A.S.M.E. meetings since the war began the technical sessions and plant inspections have been designed with emphasis on increasing production.

To Hold Student Conference Also

To conserve time and expense, and in order to make the entire meeting more attractive, arrangements are under way to combine with the Spring Meeting program the Annual Conference of A.S.M.E. student members of the engineering colleges of the Southeast. Such a combination has proved effective at the Spring Meetings of the Society held at Houston and Atlanta in recent years.

Outline of Program

The general outline of the program (subject to modification) follows:

The luncheon for all members and guests on Monday, April 3, will be addressed by a speaker whose subject will cover engineering economic conditions of the South. During the afternoon there will be an opportunity to visit plants in the Birmingham area. The evening technical sessions will be held under the auspices of the Aviation, Power, Hydraulic, and Management Divisions.

The morning sessions on Tuesday, April 4, will be sponsored by the Metals Engineering, Aviation, Fuels, and Hydraulic divisions.

Cushing, N. Y.

SKY LINE VIEW OF THE BUSINESS SECTION OF DOWNTOWN BIRMINGHAM

Registration Fee for Non-Members at the 1944 Spring Meeting

There will be a registration fee of $2 for nonmembers attending the 1944 A.S.M.E. Spring Meeting at Birmingham, Ala., April 3–5, 1944. For nonmembers wishing to attend just one session the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before March 24 asking for a guest-attendance card for the Spring Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member.*

The Tuesday luncheon will be followed by an address by R. A. Polglaze on the "Water Supply of Alabama," under the auspices of the Hydraulic Division. Tuesday afternoon the sessions will cover subjects in the field of power, hydraulics, management, and metal cutting. Dr. John M. Gallalee, member A.S.M.E., who is a consulting engineer and professor of mechanical engineering at the University of Alabama, will act as toastmaster at the banquet on Tuesday evening. President Robert M. Gates will be the speaker upon this occasion.

Wednesday morning the sessions will be devoted to the discussion of papers dealing with fuels, industrial instruments, and heat transfer. The afternoon will be given over to additional plant visits.

Birmingham Plants Open to Citizens

Plant visits during a war period are difficult to arrange. Many plants restrict admission to properly qualified citizens who can contribute their knowledge to the operating problems of the plant or to those whose own war-production problems may be helped by the application of methods to be observed in the plants visited. The American Cast Iron Pipe Company has generously agreed to open its plant to A.S.M.E. members who have proof of their citizenship. Here may be seen centrifugal pipe casting performed in a thoroughly modern plant.

The Rheem Manufacturing Company has also invited A.S.M.E. citizen members to visit its plant which is engaged in forging and machine production. It also manufactures cartridge cases and is known as one of the best production shops in Birmingham.

Other plants will be available for inspection, but as yet all the arrangements have not been completed.

Make Your Reservations Now

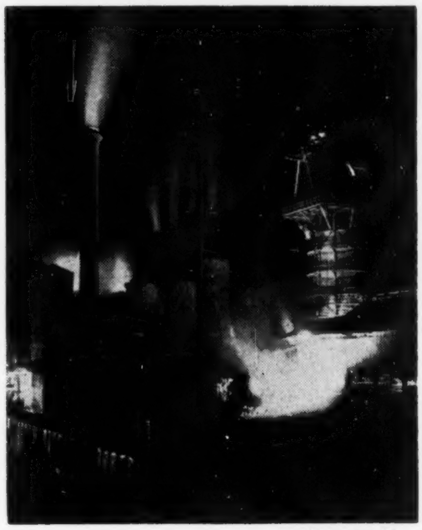
Too much importance cannot be attached to the following suggestions to all members who are in any way interested in attending the A.S.M.E. Spring Meeting at Birmingham:

1 Please write to the Secretary's Office, 29 West 39th Street, New York 18, N. Y., asking for full detailed information regarding developments in the program or any changes that may be made.

2 Members living at a greater distance than five hundred (500) miles will be sent the "Special Spring Meeting Announcement" only upon request to the Secretary.

3 Hotel reservations should be made at once. You may cancel them later, but you may not get them at the last moment.

4 Railroad reservations should be made at least 30 days in advance of the day you expect to leave for the meeting. Every day you delay thereafter will add to the difficulty of securing accommodations. You can cancel these reservations and tickets up to a short time before the hour for starting on the trip.



Cushing, N. Y.

A NIGHT VIEW OF BLAST FURNACE IN BIRMINGHAM

Tentative Program for 1944 A.S.M.E. Spring Meeting

Applied Mechanics

Stress Distribution in Welded Joints, as Shown by Transparent Models Under Polarized Light, by N. F. Bailey, Hartford Steam Boiler Inspection and Insurance Co., Atlanta, Ga.

Aviation

Session I

Aircraft Engines on the Production Line, by H. E. Linsley, public-relations director, Wright Aeronautical Corporation, Paterson, N. J.

Power by Wright—a new motion-picture sound film

Session II

Airport Development, by Charles M. Johnston, district airport engineer, Birmingham, Ala.

The Future of Aviation in the South, by Dr. M. J. Thompson, head of the department of aeronautical engineering, University of Texas, Austin, Texas

Helicopter Development (with films) by Prof. Donnell W. Dutton, head of Daniel Guggenheim School of Aeronautics, Georgia School of Technology, Atlanta, Ga.

Fuels

Session I

A Study of Stoker Fuel Beds, by Otto de Lorenzi

Federal Fuel Conservation Program, by T. C. Cheasley

Session II

An Ejector Theory and Its Applications, by Lieut. Harold G. Elrod, Jr.

Panel discussion on Pulverizer Maintenance

Heat Transfer

Temperature Distribution Within Boiler Tubing Under Oblique Radiation, by Lieut. Commander W. S. Kimball, department of marine engineering, U. S. Naval Academy, Annapolis, Md.

The Influence of Through Metal on the Heat Loss From Insulated Walls, by Victor Paschkis and M. P. Heisler, Columbia University, New York, N. Y.

Tuesday Luncheon

Hydraulic

Water Supply of Alabama, by R. A. Polglaze, Birmingham, Ala.

Certain Aspects of High-Pressure Centrifugal-Pumping Cycles, by Igor J. Karassik

Recent Axial-Flow Pumping Installations, by J. D. Scoville, S. Morgan Smith Co., York, Pa.

Industrial Instruments

Ratio and Multiple Fuel Controls in the Steel Industry, by H. Ziebolz, Askania Regulator Co., Chicago, Ill.

An Electrical-Analogy Method of Determining the Effect of Dead Time in Automatic Control, by D. P. Eckman and W. H. Wannamer, Brown Instrument Co., Philadelphia, Pa.

Management

Session I

Manpower Adjustments From War to Peace, by Dillard B. Lasseter, regional director, War Manpower Commission, Atlanta, Ga.

The Southern Economy and Manpower Utilization, by Roscoe Arant, regional consultant, U. S. Department of Commerce, Atlanta, Ga.

Session II

Introduction of Work Simplification in the Steel Industry, by A. H. Roosma, assistant manager, Southern District, Republic Steel Corporation, Gasden, Ala.

Metal-Cutting Data and Bibliography

Cutting Tools Chromium-Plated by the Lundbye Process, by Apel Lundbye, chief engineer, The Crowell-Collier Publishing Co., Springfield, Ohio

Nitriding of Hardened High-Speed-Steel Tools, by J. G. Morison, metallurgist, Landis Machine Co., Waynesboro, Pa.

Use of Low-Temperature Equipment for Treatment of Tool Steels, Deepfreeze Corporation, Chicago, Ill.

Metals Engineering

Centrifugal Steel Castings, by S. D. Moxley, ACIPO, Birmingham, Ala.

Description of Manufacture of Heavy Cast-Steel Anchor Chain, by E. V. Camp, president, E. V. Camp & Associates, Atlanta, Ga.

Power

Session I

With Hydraulic Division

Joint Operation of Steam and Hydroelectric Power Systems, by G. W. Spaulding, vice-president, Pennsylvania Water & Power Co., Baltimore, Md.

Joint Operation, by A. T. Hutchins, Commonwealth & Southern Corporation, Birmingham, Ala.

Mrs. E. C. M. Stahl Honored by Woman's Auxiliary to A.S.M.E.

MEMBERS of the Woman's Auxiliary to the A.S.M.E. who had served with Mrs. Edward C. M. Stahl during her term as president honored her at a luncheon on Tuesday, February first, at the Engineering Woman's Club, 2 Fifth Avenue, New York, N. Y.

Among the twenty-two members present were Mrs. R. M. Gates, Mrs. Harold Coes, Mrs. Clifford B. Le Page, president of the Engineering Woman's Club, and Mrs. John A. Fransema, chairman of the Philadelphia Section of the Auxiliary.

After a few words of greeting, the newly elected president, Mrs. Rudolph F. Gagg, introduced Mrs. J. Noble Landis who presented Mrs. Stahl with a Jensen silver pin and ear rings to match, a token of esteem and affection from her associates.

Card tables were set up after luncheon and many stayed to enjoy an afternoon of bridge.

Mrs. F. M. Farmer and Mrs. Crosby Field were in charge of arrangements.

N. H. Memory Honored

THE first award of the medal of Stevens Alumni Association was made at the annual dinner of the association, New York, N. Y., Jan. 21, 1944, to N. H. Memory, member A.S.M.E., assistant to the president of Stevens Institute of Technology and director of admissions and placement.

President's Page

THIS Society, with its 17,000 members, is not organized as an industry, a union, or a class. Its members are *individuals* with a variety of training and experience and with different abilities and specialties. The purpose of the Society is to contribute to the development of its individual members, to provide a medium for voluntary co-operation, and to set up standards for the profession, in order that engineers may better serve their day and generation.

President Conant of Harvard said recently: "Progress in science has been made by the unusual individual, the unorthodox individual. He cannot survive a regimented social order." That is true of American engineering. It has flourished, it has achieved, in a professional climate favorable to individual development, to individual exploration, experimentation, and specialization. We must maintain that climate and encourage that individualism.

We have before us today, as engineers, an unparalleled and almost unlimited opportunity for service. No previous generation of engineers has had a field of opportunity so broad and challenging. The world is mechanizing itself with a new determination to raise thereby its standard of living and secure freedom from want. It is demanding that we apply technology on a far larger scale and over a far wider range.

To meet this demand the individual engineer must be encouraged in every possible way—by training or retraining if necessary, by placement where he can best use his special talents, and by incentives to types of service peculiarly within his range—to develop his latent abilities and put them to work.

The nation needs, the world needs, the contribution of engineering minds to the solution of its problems. Engineering must concern itself not only with the laws of physics and mechanics, but also with applying them to human needs, with industrial relations, and with human relations. Engineers in our complex modern society often have to be managers of men, coordinators in enterprise, and co-operators in various activities. It is more than ever important now to encourage development and use of their individual capacities, whatever they may be.

In this dawn of a great advance in applying human knowledge to human welfare, we engineers are challenged to broaden our perspective and experience, to make the most of our individual capacities, and to work to the fullest limit of our powers in our laboratories, our industries, our communities, our nation.

(*Signed*) R. M. GATES, *President*, *A.S.M.E.*

Among the Local Sections

Rickenbacker Speaks at War-Production Conference of Engineering Societies

FIFTEEN National engineering societies, co-operating with the War Production Board, held the third annual War Production Conference in New York City at the Hotel Commodore on January 14. The conference, composed of 11 panel sessions, was arranged to exchange information and experience on engineering, management, shop, and manpower aspects of war-production problems. In addition, members of the Office of Civilian Requirements discussed the availability of strategic materials for the manufacture of civilian products during 1944.

One of the high lights of the meeting was the dinner address of Captain Eddie Rickenbacker, president and general manager, Eastern Air Lines, Inc. Dr. Ralph Damon, vice-president of the American Air Lines, Inc., who acted as toastmaster upon this occasion, was introduced by H. C. R. Carlson, chairman of the Engineering Societies Committee on War Production. In presenting Captain Rickenbacker, Dr. Damon stated that he was the only man who had visited all of the battle fronts throughout the world during the past year and a half.

The entire audience arose when Captain Rickenbacker stood up to speak. He gave a vivid description of his experiences for twenty-one days while on a rubber raft (or rather three rafts lashed together) in the South Pacific after a crash landing when the plane in which he was traveling overshot its island destination because of a heavier tailwind than had been expected.

He spoke in glowing terms of our troops and what they had accomplished and made one especially pertinent comment to the effect that wherever he had visited and had made any suggestions that he thought would make for better conditions these suggestions were not only carried out but that often by the time he got to the next base the suggestions had been forwarded and were already in force.

Mr. Rickenbacker dwelt at length on the Russian front as he had seen it and was tremendously impressed with Russia's accomplishments. He said that he was taken any place he asked to go and was shown anything he asked to see without reservation. He felt very proud to see the enormous quantities of war equipment which we had sent over and admitted that he had returned from Russia as an enthusiast over the country and its people—the only "allied" people who could be said to be totally at war. In Russia, he said, a person eats just in direct ratio to the way he works. If he works hard he is given better ration credit than the person who does not exert his most complete effort. The Russians are a realistic people and every last person in the country knows that this war has to be won before anything else is even considered—it is the main business of life—and Mr. Rickenbacker added that the sooner we all take the same point of view the sooner it will be over.

H. H. Dinegar at Afternoon Session

The afternoon portion of the program included the Civilian Requirements Panel with the major address by Henry A. Dinegar, Director of Durable Goods and Products Division, Office of Civilian Requirements, War Production Board, Washington, D. C. Mr. Dinegar discussed material supply, and use of substitute materials, in the production of civilian goods. A. D. Whiteside, vice-chairman, War Production Board, supplemented Mr. Dinegar's address. Other panel meetings during the afternoon were those devoted to chemical engineering, metallurgical, transportation, and safety problems. A panel on foundry-industries problems, in casting brass and light metal alloys-convened at 4:30 p.m.

Manpower Utilization

Evening panel sessions included one on manpower utilization featured by short addresses by prominent representatives of labor, management, and government. A welding-problems panel discussed latest developments in welding equipment, and methods employed in overcoming welding and flame-cutting difficulties. Problems pertaining to the manufacture of metal products, with emphasis on machining, heat-treatment, assembly, and applications of tools, jigs, and fixtures, were discussed at the production and tool-engineering panel. A second metallurgical panel was devoted to the processing and selection of national emergency steels in the manufacture of both war and civilian products. The centrifugal cast, ing of nonferrous metals and ferrous metals, as well as the production of gray-iron castings were the subjects discussed at a second foundry-industries panel.

The Societies co-operating in the arrangements for this War Production Conference by procuring speakers and panel members are as follows: American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, The Institute of Radio Engineers, The American Society of Mechanical Engineers, American Society of Civil Engineers, American Society of Safety Engineers, American Society of Tool Engineers, American Foundrymen's Association, American Society for Metals, American Society for Testing Materials, American Welding Society, American Society for the Advancement of Management, Society of Automotive Engineers, Society of Naval Architects and Marine Engineers.

War Production Conference Held at Dallas

AN Engineering and Technical Advisory Group of the War Production Committee was formed at the recent War Production Conference for Texas and Oklahoma, held at the Baker Hotel, Dallas, Texas. This group was set up as a "duration committee," whose work it is to function as a clearing house for War Production questions. Problems may be

THE SPEAKERS' TABLE AT THE DINNER OF THE WAR PRODUCTION CONFERENCE FOR TEXAS AND OKLAHOMA, HELD AT THE BAKER HOTEL IN DALLAS ON JANUARY 14

(*Left to right:* Prof. Ed. M. Harrison, Southern Methodist University; A. J. Langford, War Production Board; Lieut. George Merkel, U.S.N.R.; H. A. Sheridan, Guiberson Corporation; D. C. Pfeiffer, Dallas Power & Light Co.; Hunter R. Hughes, Southwestern editor of *Southern Power and Industry* and secretary of the Conference; Col. C. W. Crowell, Chemical Warfare; Henry M. Robinson, Federal Power Commission and chairman of the Conference; Col. Merle H. Davis, Chief, St. Louis Ordnance District and speaker of the evening; J. A. Noyes, Sullivan Machinery Corporation and vice-president of The American Society of Mechanical Engineers; Prof. C. H. Shumaker, Southern Methodist University; Col. L. P. Crim, 8th Service Command; W. E. Lind, Guiberson Corporation; Lieut. Field, Army Air Corps; E. J. Wacker, Magnolia Petroleum Corp.; Capt. R. D. Campbell, Dallas Office, St. Louis Ordnance District.)

AT THE TEXAS-OKLAHOMA WAR PRODUCTION CONFERENCE HELD IN BAKER HOTEL IN DALLAS ON JANUARY 14

(*Left to right:* David C. Pfeiffer, Dallas Power & Light Co.; E. J. Wacker, Magnolia Petroleum Corporation; Philip M. Cordell, Texas Electric Co.; J. F. Schwegmann, Dallas Power & Light Co.; W. O. Beeman; and Henry M. Robinson, Federal Power Commission, and chairman of the Conference.)

described in writing and sent to the Secretary of the War Production Committee, who in turn will turn them over to an expert in that field. There will be no charge for this service and it will in no way replace the services of a consulting engineer.

Panels at Conference

Instead of the presentation of papers by the leaders, panels were held at the Conference as follows: From 1:00 to 5:00 in the afternoon and from 8:00 to 12:00 at night. Afternoon panels were devoted to inspection problems, supervisory training, electrical maintenance, heat-treating, metals forming, and protective coatings. The evening panels were on machine-tool problems, employee problems, mechanical maintenance, production training, welding, and lighting.

"War Department Report"

Herman Hart, of Wyatt Metal and Boiler Works, Dallas, explained how his company solved the problem of welding 20-gage copper to steel without burning the copper. At the informal dinner, Col. Merle H. Davis, chief, St. Louis Ordnance District, spoke of the current trends in war production, the greatest part of his speech being devoted to the vital subject of contract termination. Col. Davis' speech was followed by an interesting film, "War Department Report," which showed, from captured German and Japanese films, the enemy's war-production effort.

Producing Super Aviation Gasoline by Means of a New Process

T. P. Simpson Describes Method at Southern California Section

DRAMATIC revelations regarding the process developed and now in use in this country for the manufacture of a vastly superior aviation gasoline, which enables Allied air fighters to take off more quickly, fly faster and farther, and carry heavier bomb loads with which to overwhelm the enemy, were made by T. P. Simpson, at a dinner meeting of the Southern California Section held in Los Angeles, on January 18. Approximately 400 members of the Society and their guests attended. Frequently referred to as creator of the idea through which the new process came into being, T. P. Simpson of New York is assistant chief of the research and development department of the Socony-Vacuum Oil Company which holds the basic patents on a new process of producing this gasoline of superperformance characteristics.

Because of its recognized importance in helping to speed the end of the war, and the request of the government for an increasingly large flow of the superfuel, the process has been made available by Socony-Vacuum to all other oil companies. Mr. Simpson stated that more than 30 plants will be in operation by the end of this year, supplying the air arm of the fighting forces with what is virtually recognized as a new secret weapon.

Description of the new method of aviation-gasoline production is hardly understandable to the lay mind, but the method of manufacture includes a vast maze of fractionating towers, furnaces, reactors, and other components of expensive equipment which were described in detail to the engineers.

A highly interesting phase of Mr. Simpson's address was his description of the little beads, billions of which constantly flow through the reactors of the super 100-octane gasoline plants, transforming by mere contact the low-octane vapors into materials of exceptional aviation quality. The new fuels give Allied fliers that critical margin of superiority in combat that decides which of two opposing pilots is to come home.

California Large Producer of Super Aviation Fuel

S. J. Dickey, president of General Petroleum Corporation, Los Angeles, whose company recently dedicated its super 100-octane plant, gave an informative address in which he revealed the important part of the California oil industry in the war, assigning this as the reason for the gradually decreasing flow of gasoline for civilian use.

Stressing the big job that has been placed on the shoulders of the oil industry, particularly in California, Mr. Dickey asserted that Pacific Coast refineries are now turning out 30 per cent more gasoline than before Pearl Harbor. He said that twice as much aviation gasoline is being made from each barrel of California crude oil as from the crude of other parts of the country.

Carbide-Tipped-Tool Usages Cited at Akron-Canton

Practical design, manufacture, and use of sintered-carbide-tipped tools, with specific applications and performance figures, were ably discussed and illustrated by E. V. Johnson of The Firth-Sterling Steel Company, before the Akron-Canton Section on January 27, which met in the Women's City Club, Akron, Ohio. Sixty-one members and guests were present.

Birmingham Section Holds Dinner Meeting

A dinner, prior to its meeting, was given by the Birmingham Section in honor of Dr. John E. Younger, guest speaker at the January 25 meeting of the organization. Approximately 150 members and guests assembled at Tutwiler Hotel, Birmingham, Ala. Dr. Younger, an aviation authority and head of the mechanical-engineering department, University of Maryland, illustrated his lecture in a delightfully popular fashion.

Joint Meeting Held by Atlanta Section

A joint meeting of the Atlanta Section and the Georgia Engineering Society was held on January 3, at the plant of the Davison Pavon Company, Atlanta, Ga., to hear E. V. Camp, of the National Traffic Guard Company, speak on the subject of "Conversion of Steel Plants to Essential War Products." Mr. Camp discussed the activities of his company in the war-production effort, which included the manufacture of ship anchors, anchor chains, rudders, as well as heat-treating and casting of steel.

Screw-Thread Grinding Subject at Boston Section

The Boston Section met on January 13 at Boston, Mass., to hear Ernest Flanders speak on the subject, "Screw Thread Grinding." Mr. Flanders discussed the importance of screw threads in mechanical construction, something of their history, and then described the equipment and methods which have been developed in the last few years to place screw

threads on the same plane as to accuracy and finish that external and internal grinding have occupied for so many years. An instructive film on the operation of the J.&L. screw grinder and samples of work done on these machines were displayed.

Bridgeport Section Hears About Industrial Electronics

At the Bridgeport Section meeting at Boroughs Library, Bridgeport, Conn., on January 20, W. Scott Hill, of the New York district of General Electric Company, spoke on "Industrial Electronics." Mr. Hill's subject dealt mainly with the application of electronics to the mechanical field. He discussed rectifier installations in the electrochemical field; phototubes for the utilization of light, color, and temperature variations; electronics in welding; and variable-speed motor drives. He also explained the reasons why electronic devices of all types are able to perform at seemingly incredible speeds.

Two Meetings Held by Chicago Section

Members of the Chicago Section met on January 10 to hear W. W. Davies, of the United Air Lines Transport Corporation, speak on "Possibilities in Future Air Transportation." Mr. Davies reviewed the past history of airplane technical development and discussed future developments in wing design, engines, and propellers, materials, instrumentation, maintenance and repair, and airports.

On January 24 this Section met again to hear H. L. Moir discuss the subject, "Recent Developments in the Testing of Cutting Fluids." With the aid of excellent photographic lantern slides and various graphical material, Mr. Moir presented in an understandable manner the function and use of cutting fluids, illustrating the conclusions by showing the finished products, with and without the use of a cutting fluid.

Subject at Cleveland Section Is Pipe Line "Big Inch"

The Cleveland Section held a meeting on January 13, at which L. S. Shearer, War Emergency Pipelines, Inc., spoke on the subject of "The Big Inch." He gave a description of the well-known oil pipe line "Big Inch," including the pumping stations and the method of operating the line. Mr. Shearer then high-lighted the subject by the movie, "Oil for War."

Dean Woolrich Speaks at Colorado Section

On January 17 the Colorado Section met to hear Dean W. R. Woolrich talk on "Theories and Processes of Quick Freezing." Dean Woolrich outlined various forms of food preservation and their value to the public, describing the latest and most effective methods of freezing of foodstuffs, particularly new machinery developed by himself and associates at the University of Texas for this purpose.

Joint Meeting Held at Columbus Section

Dr. H. J. Grover, research physicist, Battelle Memorial Institute, on January 18 addressed a joint meeting of the A.S.M.E. and A.I.E.E. at the Columbus Section on the subject, "Engineering Applications of Resistance-Type Strain Gages." Dr. Grover discussed the types and applications of these gages, as well as some of their theory, illustrating his talk by slides.

East Tennessee Section Hears F. J. Stevens

The East Tennessee Section held a joint meeting with the A.I.E.E. on January 11, at the S.&W. cafeteria, Knoxville, Tenn., to hear F. J. Stevens speak on the subject of "Some Notes on London." Three members and 20 visitors were present.

This Section met again on January 24, at the University of Tennessee Alumni Memorial Auditorium, Knoxville, with a large attendance of 1250, to hear Dr. John E. Younger speak on the subject of "Fundamentals of Pressure-Cabin Operation."

Fort Wayne Section Gets Radiography Details

At the January 12 meeting of the Fort Wayne Section, Y.M.C.A., Fort Wayne, Ind., W. L. Fleischmann spoke on the subject of "Industrial Radiography." Mr. Fleischmann discussed the history and applications of industrial radiography and illustrated the applications of the absorption and defraction types of X-ray examination with slides.

Engineers' War Conference Program Scheduled for Hartford Section

The Engineers' War Conference, sponsored by the War Production and Engineering Council (for northern Connecticut), will be held by the Hartford Section, at Hotel Bond, Hartford, Conn., on February 16, with A. H. d'Arcambal, as toastmaster. Speakers during the dinner will be: John H. Hurley, representing Mayor Mortensen; Honorable Raymond H. Baldwin, Governor; C. A. Woodruff, chairman, Area Production Urgency Commission, W.P.B., who will speak on "War Production Needs for 1944;" and Dr. Lawrence W. Bass, director, New England Industrial Research Foundation, who will discuss "Improved Technology in War and Peace."

Inland Empire Meeting Hears How Turbine Models Aid Production

A meeting was held on January 15 by the Inland Empire Section, at the Davenport Hotel, Spokane, Wash., to hear David W. R. Morgan, vice-president, A.S.M.E., speak on the subject of "Geared Steam-Turbine Units for Marine Service." Mr. Morgan said that models of gear cases have saved considerable production time, since without extensive study, comparatively few unskilled workmen would understand blueprints. He stated that although surface condensers have been improved in recent years, there is room for further improvement in design.

The 77th Evacuation Unit Is Topic at Kansas City

Lieut. Col. E. H. Hashinger, U. S. Army Medical Corps, chose as his subject at the January 11 meeting of the Kansas City Section, "The 77th Evacuation Unit in Africa, Sicily, and Italy." He said that the 77th Evacuation Unit was made up of doctors and nurses from the University of Kansas Hospital. He told in detail how the unit, after training in the United States and England, had arrived at Oran, followed the fighting fronts in Africa, Sicily, and Italy, and that on one occasion had almost fallen into the hands of the enemy.

Precision Measurements Topic at Louisville Section

Louisville Section met on January 20 and heard C. C. Hartwig speak on the subject of "Precision Measurements in Industry." Mr. Hartwig described the use of optical flats and interference bands in ultraprecision measurements and presented methods of using gage blocks through simple instruments for inspection gaging.

Dr. J. E. Younger Addresses Memphis Section

In an address on January 21, at the Memphis Section, Dr. J. E. Younger described the "Fundamentals of Pressure-Cabin Operations at High Altitude." After his speech, an open discussion was held, and Dr. Younger explained many aircraft structural problems to the members and visitors in attendance.

Metropolitan Section Will Hold Meeting in March

The Junior Group of the Metropolitan Section will hold its monthly meeting on March 28, at Child's Restaurant, 109 West 42nd Street, New York, N. Y. The subject of the meeting will be "Some Aspects of Refinery Design and Construction." This meeting will represent a departure from the customary practice of having a single speaker address the group, and will consist of a forum-type discussion.

Alloy Steels Is Subject at New Haven Section

On January 19, the New Haven Section met to hear J. P. Gill, vice-president and chief metallurgist, Vanadium Alloys Steel Company, discuss "Tools and High Speed Steels." Mr. Gill gave a concise description of the various classes of alloy steels and their action in affecting the qualities of steel with respect to growth, depth of case, grain size, red hardness, and toughness.

Aircraft Structures Discussed at North Texas Section

On January 19, the North Texas Section held a joint meeting with the Texas Chapter of the

S.A.E., at the Dallas Power & Light Company plant Dallas, Texas, to hear Dr. John E. Younger speak on "Aircraft Structures Past, Present, and Future." Dr. Younger discussed the development and possible future of wing design, particularly the monocoque structure, and illustrated his lecture with slides. An open discussion was then held by Mr. Robbins of Consolidated, Forth Worth, Texas, plant.

Dinner Meeting Held by Piedmont Section

A dinner meeting was held by the Piedmont-North Carolina Section on December 16, at the Yakin Hotel, Salisbury, N. C., at which Henry Kreisinger, manager of development and research, Combustion Engineering Company, Inc., New York, spoke on the subject of "Future of Coal." Mr. Kreisinger's talk was technical yet practical enough to prove very interesting to the large attendance present. A question period followed his comments. About 120 members and guests were in attendance, which included 27 student members and naval training students from Duke University.

Providence Section Hears R. H. Rogers

The Providence Section held a meeting on January 4, at which R. H. Rogers, of the General Electric Company, spoke on the subject of "Electronics in Industrial Control." Mr. Rogers described applications of electronics in resistance welding, precision control of heat in furnaces, rectifiers for substations changing a-c to d-c and converting d-c to a-c.

This Section met again on January 26, to hear Lieut. Col. G. R. Jarrett give a talk on "Analysis of Enemy Weapons." He described weapons and vehicles captured in North Africa by the 8th Army and showed lantern slides to illustrate his various points. He then analyzed the captured weapons, which involved metallurgical and chemical tests to determine efficiency of ammunition, armor plate, gun operation, and horsepower of the vehicles used.

Prominent Speakers Discuss Postwar Planning at Raleigh Section

Prominent speakers discussed "Postwar Planning," at the January 28 meeting of the Raleigh Section. Members and guests, who assembled at the Sir Walter Hotel, Raleigh, N. C., heard talks by Hon. J. Melville Broughton, Governor of North Carolina; Thomas H. MacDonald, F.W.A.; Samuel F. Newkirk, superintendent and engineer, Water Commissioners; W. H. Weatherspoon, vice-president, Carolina Power & Light Company, and Charles Ross, of the State Highway Commission.

Petroleum Supply Estimates Made at St. Louis Section

According to R. A. Sherman, supervisor of Fuels Division, Battelle Memorial Institute, present estimates indicate that the petroleum supply in the United States will be available for a period of only 14 years. Mr. Sherman made this announcement at a meeting, on January 28, of the St. Louis Section, in the Forrest Park Hotel, St. Louis, Mo. He continued, however, that this could be extended by more efficient boilers and engines and by the use of coal for heating instead of oil. Mr. Sherman believes the coal supply is good for more than 4000 years.

Postwar Use of High-Octane Gasoline Is Discussed at San Francisco Meeting

The San Francisco Section met at the Engineers' Club, San Francisco, Calif., on January 20, to hear Dr. A. G. Cattaneo speak on the subject of "Postwar Effect of High-Octane-Gasoline Developments." Dr. Cattaneo contended that 100-octane gasoline would not be available in large quantity for postwar automotive use. He explained the conditions and facts leading to his findings and concluded that the postwar position of higher-octane gasoline would be no better than could be expected from the normal development that would have occurred had there been no war.

This Section met again on January 27, at the Engineers Club, to hear George C. Tenney, president of the McGraw-Hill Book Company, Inc. of California, speak on the subject of "Pacific Coast Power Supply—Present and Future."

Mr. Tenney covered developments which have been occasioned by the war, including the expansion of the large Federal hydroprojects pool operating in the Pacific Northwest and Southwest.

Group 7 Nominating Committee Members from San Francisco

Messrs. Walter Kasselbohm and Alf Hansen of the San Francisco Section were elected member and alternate, respectively, from Group 7 on the Nominating Committee of the Society. Group 7 is composed of the following sections: Inland Empire, Oregon, San Francisco, Southern California, Utah, and Western Washington.

A rotation scheme was established by Group 7 some years ago so that the members of the Nominating Committee are appointed from the various local sections of the group in rotation. This year it was San Francisco's turn to have a member and alternate on this important committee.

Lignite as a Texas Fuel at South Texas Section

C. J. Eckhardt, professor of mechanical engineering and superintendent of utilities of the University of Texas, spoke on the subject of "Physical Properties and Potentialities of Lignite as a Texas Fuel," at a meeting December 15, of the South Texas Section. Mr. Eckhardt discussed the physical properties of lignite and also the reserves of lignite as compared to other mineral reserves in Texas and the United States. He showed a number of slides to illustrate his talk.

Utah Section Reports 1943 Meetings

The Utah Section met on September 20 at Salt Lake City, Utah, to hear L. Dahl Simmons, building supervisor at the Utah Ordnance Plant, speak on the subject of "Employee Relations." Mr. Simmons outlined some of today's labor problems and possible means whereby all available labor can be utilized to the best advantage. He also presented a film on the subject.

This Section met on October 18 to hear E. J. Williamson, chief chemist, Utah Ordnance Plant, speak on the subject of "Wonder World of Chemistry." After his lecture he showed an interesting film on the subject.

Eugene L. Koffman, designing engineer for the Utah Copper Company, speaking on the subject of "Russian Industry," at the November 22 meeting of this Section, told members that output per worker in Russian industry is only 45 per cent of that in American industry. The difference is due in part, he said, to the tremendous tempo of industrialization which took place in Russia in the 10 years from 1930 to 1940.

At the fourth and final meeting on December 27, three sound films were presented, "Building a Bomber," which described the B-26 Army medium bomber; "Building a Tank," describing the construction of the M-3 medium tank, and "Target for Tonight," an account of an actual air raid by the Bomber Command of the Royal British Air Force.

West Virginia Section Holds Dinner Meeting

The West Virginia Section held a dinner meeting on February 22, at the Daniel Boone Hotel, Charleston, W. Va., at which James H. Herron, of the James H. Herron Company, spoke on the subject of "Engineering Profession." Mr. Herron is a past-president of the A.S.M.E. and a member of the Council.

Radio Principles Explained at Western Massachusetts Meeting

Explaining how the size, shape, and distance of an object can be determined by the use of radio equipment, Paul H. Nelson, assistant professor of electrical engineering, University of Connecticut, high-spotted the monthly dinner meeting of the Engineering Society of Western Massachusetts held in Springfield, Mass., on January 18.

Prof. Nelson reviewed the history of radio waves for the past 100 years, beginning with its discovery by Faraday to 1890 when experimental checks were conducted, then to Marconi, who in advancing the application of the so-called long waves, actually retarded the progress on the short or ultra-high-frequency waves. Recent developments actually started in 1920 when it was noted that radio waves were disturbed by certain objects in their path, such as mountains and ships passing between the transmitter and receiver. Studies were made and it was found that by increasing the frequency to extremely high fields, which in turn reduces the wave length, a wave could be transmitted which, on striking an object,

would be reflected back to a receiver. The use of these principles has been highly effective in many war instruments at sea and on land.

Condensers and Pumps Subject at Western Washington Section

Members of the Western Washington Section met at the Gowman Hotel, Seattle, Wash., on January 17, to hear D. W. R. Morgan speak on the subject of "Condensers and Pumps." Mr. Morgan outlined in an interesting manner the problems encountered in condenser design.

Midwest Power Conference To Be Held in Chicago, April 13 and 14

THE seventh annual Midwest Power Conference, arranged by the Illinois Institute of Technology, will be held April 13 and 14 at the Palmer House in Chicago, Ill., and will emphasize both war and postwar power problems.

The tentative program, which already includes 20 topics, will revolve around the following nine sessions: the opening general meeting, three electrical meetings, power-plant practice, industrial power plants, plant maintenance, fuels, and Diesel power.

Keynote speaker will be Alex D. Bailey, fellow A.S.M.E., assistant to the vice-president of Commonwealth Edison Company in Chicago. He will speak on "Postwar Planning of the Nation's Power Supply."

J. A. Krug, director of the office of war utilities of the War Production Board in Washington, D. C., will be the featured speaker at the All-Engineers' Dinner, annual social high light of the conference.

As in former years, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers will each sponsor a conference luncheon. Speakers will be B. W. Clark, vice-president in charge of sales, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and Dr. C. O. Dohrenwend, chairman of engineering mechanics research at the Armour Research Foundation at Illinois Tech.

Originated in 1926 in Chicago as a private venture, the Midwest Power Conference has developed to its present stature since its reorganization in 1938 as a co-operative venture. The conference is now sponsored by Illinois Tech, with the co-operation of eight other schools and eight engineering societies.

Schools working with Illinois Tech in sponsoring the conference include: Iowa State College, Michigan State College, Northwestern, Purdue, Iowa, Illinois, Michigan, and Minnesota Universities.

The eight engineering societies included in the planning and sponsoring are: Chicago sections of the American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers and The American Society of Mechanical Engineers; Illinois sections of the American Society of Civil Engineers and the American Society of Heating and Ventilating Engineers; Western Society of Engineers; and the Engineers' Society of Milwaukee.

Navy Methods of Packaging, Packing, and Materials Handling to Be Discussed in New York, March 17

ENGINEERS who witnessd with enthusiastic appreciation the motion pictures presented under the auspices of the Materials Handling Division, at the 1943 A.S.M.E. Annual Meeting, which showed recent advances made by the U. S. Navy in materials-handling methods, including the training of workers, will want to attend the A.S.M.E. Metropolitan Section meeting, Engineering Societies Building, New York, N. Y., Friday, March 17, at 7:30 p.m.

Movies at New York, March, 17

At the Metropolitan Section meeting, which is jointly sponsored by the Materials Handling, Industrial Conservation, Management, and War Production Divisions of the section, the subject is to be "New Developments in the U. S. Navy in Packaging, Packing, and Materials Handling." There will be new motion pictures and slides to illustrate the talks by the four speakers. Three of these speakers appeared on the Annual Meeting program.

Navy Experts to Speak

Commander Onnie P. Lattu, Supply Corps, U.S.N., officer in charge of Containers and Materials Handling Section, Stock Division, Bureau of Supplies and Accounts, Navy Department, Washington, D. C.

Lieut. (j.g.) Walter T. Sheldon, Naval Cloth Depot, Navy Department, Brooklyn, N. Y.

Curtis H. Barker, Jr., technical director, Containers and Materials Handling Section, Stock Division, Bureau of Supplies and Accounts, Navy Department, Washington, D. C.

Nathan W. Potts, Eastern Industrial Sales Company, New York, N. Y., formerly technical associate, Containers and Materials Handling Section, Stock Division, Bureau of Supplies and Accounts, Navy Department.

Mr. Barker is secretary of the A.S.M.E. Materials Handling Division's executive committee and Mr. Potts is an associate member of that committee.

A Few Hints About the Program

The Navy Department has set up and carried on one of the largest undertakings in history for the assembling, classifying, storing, shipping, and handling of materials at the 10 Navy Bases and hundreds of points to which these materials must be delivered at home and abroad.

Methods of packaging and packing these supplies have also been developed and will be described.

A Chance for Other Sections

Attendance at this Metropolitan Section meeting is open to all who are interested and concerned with materials-handling, packaging, and packing problems in industrial, transportation, or governmental operations.

It is understood that the Navy is willing to co-operate with technical associations in any reasonably large center in putting on a similar meeting. Here is an opportunity for other A.S.M.E. local sections to enrich their programs with a meeting of vital interest. Why not send a representative to "scout" the Metropolitan Section Meeting March 17?

Information Requested for 1944 A.S.M.E. Membership List

CARDS have recently been mailed to members of the Society asking for information for the 1944 A.S.M.E. Membership List, which is to be published as Section Two of a summer issue of the Transactions and distributed to all members regularly receiving A.S.M.E. publications.

Because of wartime paper restrictions the book will contain only an alphabetical address list and the Consulting Engineers Index. The committee personnel section has already been published as a separate pamphlet and may be obtained upon request; and the Constitution, By-Laws, and Rules, with revisions since its publication as part of the 1942 Membership List, will also be issued in pamphlet form, obtainable upon request, later in the year.

Return Card Promptly

Those engaged in consulting-engineering practice who desire to be listed in the Consulting Engineers Index should return both the Membership List information card and the Consulting Engineers Index card which accompanies it so that they will reach the Secretary's Office, 29 West 39th Street, New York 18, N. Y., by March 20, 1944. Members located outside the United States who may not be able to meet that date are asked to return the Membership List card for the correction of address files.

Note Changes in Professional Division Registration

It will be noted that members are asked to number, in the order of their preference, all the professional divisions in which they are interested, even though, as at present, only the first three will be used for professional divisions mailings.

Members in Armed Forces to Be Designated

A new feature of the 1944 Membership List will be the designation of members in the armed forces of the United States. In order that this record may be as complete and up-to-date as possible, in cases where the member himself cannot be reached, cards will be sent to home or former business addresses, if available, and relatives or friends receiving them are requested to return them, with as much information as can be supplied.

Members are urged to follow directions on the cards carefully to insure correct listings and to return the cards promptly to expedite the publication of the book.

With the Student Branches

Arkansas Branch Hears Two Speakers

On December 15, the ARKANSAS BRANCH met to hear Harlan Holmes and Durbin Miller speak on "Oil-Well Drilling," and "Aluminum," respectively. Mr. Holmes gave in his talk the mechanical equipment and operations connected with the drilling for oil, also discussing briefly the seismographing and Schlumberger processes. Mr. Miller discussed the properties of aluminum as well as some of its applications under the present world conditions. The speeches were given at a "smoker" held by the members.

CALIFORNIA TECH BRANCH met on January 5, to elect officers for the ensuing year. They are Jack Kettler, chairman; Donald Greenwood, vice-chairman, and D. B. Smith, secretary-treasurer.

On December 9, the DETROIT BRANCH held a meeting at which Al Paccini of The Detroit Edison Company gave a short talk on power generation. An interesting round-table discussion followed Mr. Paccini's comments. A musical program for the January meeting of this Branch also was discussed.

J. H. Billings Stresses Good Craftsmanship at Drexel

The final fall-term meeting of the DREXEL TECH BRANCH was held on December 7, at which reports were heard from members who attended the A.S.M.E. Annual Meeting in New York, N. Y. Prof. J. H. Billings, member A.S.M.E. and head of the mechanical-engineering department, gave a short talk on good craftsmanship stressing the importance of doing menial and apparently inconsequential jobs to the best of one's ability. The guest speaker, Prof. Charles L. Tutt, Jr., of Princeton, member A.S.M.E. and secretary of the Production Engineering Division, delivered an illustrated lecture on "Production Engineering and the War Effort." Various time- and material-saving processes were used as illustrations to prove the value of advancement in production engineering.

This Branch met again on January 12, with the Philadelphia Junior Section, and the Penn and Villanova Branches, to hear Major Ehrmann, bomb disposal instructor at the Aberdeen Proving Ground, speak on the subject of "Bombs and Booby Traps."

On the afternoon of January 27, a group of the Drexel Branch enjoyed an inspection trip to the Supplee Ice Cream Plant at 34th and Market Streets, Philadelphia, Pa. The trip was arranged with F. J. Carabello, a Drexel graduate now associated with Supplee.

A list of nominees for officers for the coming year was presented at a meeting on January 12 of the ILLINOIS BRANCH, which was accepted as recommended by the committee. Prof. Espy then spoke to the group present on "Energy, Entropy, and Mechanical Engineering," after which he made additional comments on a paper entitled, "The Second Mile."

This Branch met again on January 19, at which the results of the election of officers for the coming semester were announced as follows: W. D. Stroud, president; R. L. Allen, first vice-president; D. R. Denis, second vice-president; D. O. Wilson, secretary, and C. R. Rankine, assistant treasurer, who will automatically replace Keith Banner as treasurer, upon the latter's graduation. At the close of the business session, Prof. Findley gave an interesting talk on "Plastics," describing a few of the many different kinds and manufacture of plastics. Illustrative slides were shown.

At a meeting on December 1, of the IOWA STATE BRANCH, an announcement was made by R. C. Smith, president, that an A.S.M.E. picture would appear in the "Bomb," the I.S.C. Year Book. Prof. D. L. Arm introduced Chief Petty Officer Suchar of the Navy, who related his experiences in the operation and care of marine engines under actual battle conditions.

This Branch met again on December 8, at Myers Photographic Studio, Ames, Iowa, for the "Bomb" I.S.C. Year Book picture. The group then retired to Engineering Hall for an election of officers. The officers elected are H. A. Dipple, president; M. B. Purvis, vice-president; Sol Bucksbaum, secretary, and R. D. Hug, treasurer.

The first meeting of the winter quarter of the Branch was held on January 12. After a short business session, the group went on an inspection tour of the Navy Diesel laboratory, where Prof. David L. Arm spoke a few words on the origin and use of the laboratories.

A joint meeting of the UNIVERSITY OF KANSAS BRANCH with the A.S.C.E. was held on December 9, to see silent films on bridge building, on the fabrication of copper, and a sound film on abrasives. Prof. Hay discussed the film on bridge building at great length.

This Branch met again on January 6, to discuss A.S.M.E. membership and future programs. The main attraction of the evening, however, was the presence of Prof. Wheeler, psychologist, guest speaker. Prof. Wheeler has made some very interesting experiments with rats, and his two-hour discussion proved extremely interesting and exciting to the 20 members and 10 visitors present.

The LAFAYETTE BRANCH participated in a joint society meeting on February 2, at Pardee Hall, Lafayette College, Easton, Pa. George Diehl of the Ingersoll-Rand Company, spoke on "Stress Measurements by Electronic Methods." Mr. Diehl explained the construction of the instruments with the aid of diagrams. A demonstration then was given with the aid of an oscillograph, after which

A.S.M.E. STUDENT BRANCH AT UNIVERSITY OF NEW HAMPSHIRE, JANUARY, 1944
(*Front row, left to right:* H. M. Wuth, H. F. Szczepan, E. P. Nye, R. J. Milas, V. E. Sanborn. *Back row, left to right:* Donyal Kerven, H. S. Hoch, V. F. King, A. S. Harding, R. B. Cahall, R. E. Morang, V. B. Wilkens, F. J. Wakefield.)

many questions were asked by the audience.

The first meeting of the winter quarter of the LOUISIANA BRANCH was held on December 13, at which plans were made for increasing the membership of this organization. New committees were appointed to bolster the work of the Branch.

Objectives of A.S.M.E. Reviewed at Michigan Branch

The first meeting of the winter term of the MICHIGAN MINING AND TECH BRANCH was held on January 11. A review of the "Objectives of the A.S.M.E." was given by the chairman. Announcements also were made regarding the election of new officers, and A.S.M.E. papers, prizes, and awards for contest winners. The members then entered into an informal discussion on the "Manpower Situation at Present," which was followed by a general discussion of "Government Operation of Railroads."

This Branch met again on January 25, at which meeting a letter from the National Headquarters, concerning the contest to be held at the University of Minnesota, wal read by the acting secretary. Nominations for officers were made as follows: Mr. Ellerthorpe, chairman; Mr. Larson, vice-chairman; Messrs. Lichtenstein and Hayden, secretary, and Mr. Duiser, treasurer. Two subjects then were discussed, namely, "The Transportation Problem," and "Government Ownership of Railroads."

Three films were enjoyed by members of the MINNESOTA BRANCH, which met on January 12. Two of the films were about spark plugs and showed how they are made, how they function in an internal-combustion engine, and how they are repaired and inspected after use. The third film was a composite of many scenes from different races where the internal-combustion engine was used as the motive force. Scenes from automobile, motorcycle, inboard and outboard boat, and airplane races were shown. Between the second and third films, Prof. Holtby, honorary chairman of the student branch, gave a brief talk.

The MISSOURI BRANCH held its first meeting of the new term on January 12, in the Engineering Building of the University. Robert Toal, in charge of the "social" scheduled for the next meeting, announced that guests from Stephens College were expected to be present. After the business session, an interesting film, "Wright Builds for Air Supremacy" was shown.

Edison Cell Battery Films at New York Branch

Twenty-four members and 3 guests were present at a meeting on December 1 of the NEW YORK UNIVERSITY EVENING BRANCH to see two interesting motion pictures on the Edison cell battery in industry. The pictures, which were presented through the courtesy of Thomas Edison, Inc., and Bill Plenty of the Branch, particularly emphasized the use of these batteries in battery-powered loading and unloading trucks. Following the films, plans for a dance were discussed. Details of date, and the like, were deferred for a later meeting.

Prof. Wolowicz of the engineering department of the NORTHEASTERN BRANCH, at a meeting on January 6, spoke on the subject of "Aircraft." He outlined the procedure involved in designing a new plane, mentioning some of the difficulties encountered. He stated that aeronautical engineering is a combination of all engineering—civil, mechanical, etc.—and earnestly suggested that each engineer specialize in and become expert in one particular phase of the field.

Photo by Morton Kaganowich '44

SENIOR-FACULTY BANQUET GIVEN BY THE SENIORS IN THE COLLEGE OF ENGINEERING AT RUTGERS UNIVERSITY, NEW BRUNSWICK, N. J.

(Faculty members of the College of Engineering were present. Raymond Miller '44 E.E., the toastmaster, is shown speaking.)

This Branch met again on January 20 to hear Prof. Pinard speak on a subject quite unrelated to engineering. Prof. Pinard chose as his topic, "Courtship, Engagement, and Marriage." He briefly outlined the disintegration of family, how to preserve the family, what to look for in selecting a mate, and the like. Eighty-two members were present.

OHIO STATE BRANCH on December 17 held a regular meeting to hear Prof. S. M. Marco, faculty adviser, speak about The American Society of Mechanical Engineers. Prof. Marco outlined the national and local organizations; the benefits derived from being an affiliated member; the financial responsibility, and then suggested that the question of dues be discussed at the next meeting. After Prof. Marco's discussion, James Smelker recommended that a junior and a senior mechanical engineer be elected to the Student Engineers' Council.

This Branch met again on December 31, at which a motion was passed that the quarterly local dues of 50 cents and lounge fee of 25 cents be the same as heretofore. At the same time Robert Love and Norman Hopwood were elected senior and junior mechanical-engineering students to serve on the Engineers' Council. Robert Hyatt, chairman of the American Society of Automotive Engineers, then gave a short talk on the advantages of being a member of this Society, while Prof. Younger of the industrial-engineering department, spoke on the subject of "Simultation."

On January 14 this Branch met to hear Prof. Shank of the civil-engineering department give a talk on the A.I.U. tower foundation and other similar foundation constructions. Thirty-nine members and one visitor were present.

A meeting of this Branch was also held on January 28, at which Prof. S. R. Beitler spoke on the "Manufacture and Testing of Wire-Wrapped Pipe." His speech included both laboratory tests and tests conducted in the field.

New appointments to the program and publicity committees were announced at a meeting of the OKLAHOMA A.&M. BRANCH on January 17. They include Robert Abernathy, James P. Jones, and Jack Teverbaugh, program committee, and A. McNaughton and Joseph Dawes, publicity committee. The speaker of the evening was Prof. William Rice, department of engineering, who talked on materials and processes used in aircraft construction. From extensive experience gained while affiliated with the Cessna Aircraft Corporation, Prof. Rice was able to give many practical side lights on the subject.

Boeing Flying Fortress Shown in Color Film at Purdue

On January 12, the PURDUE BRANCH met to enjoy a film, in color, depicting the Boeing flying fortress. The film described research and production at the Boeing laboratories and factories. Part of the film showed research being conducted in a refrigerated chamber to find suitable lubricants for use at temperatures about 75 F below zero, the temperature of the stratosphere. It also showed research done to perfect the turbosupercharger, an essential part of the plane that flies 35,000 ft above sea level. Scenes then showed hundreds of the many women at work building bombers. After the film, Staff Sergeant Malone, one of the trainees in the Army specialized training program stationed at Purdue, answered numerous questions raised by the audience.

W. C. Osborne, an instructor in the mechanical-engineering department and formerly connected with Worthington Pump & Machinery Corporation, Harrison, N. J., was guest speaker at a meeting on January 13 of the RENSSELAER BRANCH. His topic, "You and Your Graduation Thesis," thoroughly described the two classifications of graduation theses; namely, research and design. Slides were shown illustrating many features of

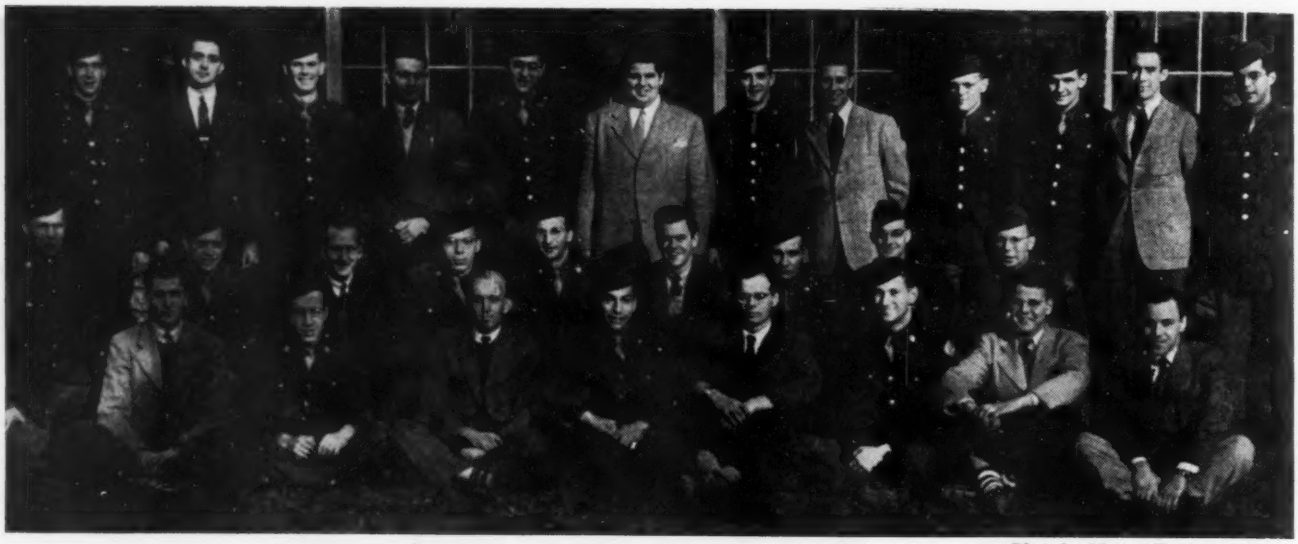


Photo by Morton Kaganowich '44

MECHANICAL ENGINEERING STUDENTS AT RUTGERS UNIVERSITY, NEW BRUNSWICK, N. J., WHO WERE GRADUATED IN JANUARY, 1944, CIVILIANS AND A.S.T.P. MEN

(*Left to right, first row:* Clifford Whelan, Philip Watterson, Donald Malony, Fredric Holtzberg, Harold Johnson, Richard Rossback, Chester Wcislo, Matthew Lafer. *Second row:* Charles Sundquist, Max Butler, James West, Joseph Erwin, Peter Huryn, Donald MacNair, George Staats, William Savery, Arnold Grayzel. *Third row:* Ernest Toepletz, Edward Welch, Ralph Johnson, Henry Rottersman, Douglas Kahn, Ned Bowen, James Pierson, Louis Pelosi, Norman Schoij, Raymond Smith, John Gaston, Walter Heckman.)

prize-winning theses of the past. After the speech, plans were discussed for a joint meeting with the Rensselaer Polytechnic Institute student branch of the A.I.E.E. Dr. Moss, inventor of the gas turbine, was scheduled to be the guest speaker.

Committee Work Active at Rutgers Branch

An organization meeting was held on January 20, by the RUTGERS BRANCH. The discussion was opened for suggestions for the programs of future meetings, at which time Sam Goldfarb requested more student talks and the presentation of papers by students; Al Walker proposed inspection tours through defense plants, and Pfc. Bert Levitan, a visiting A.S.T.P. student, mentioned that many army students were interested in joining the Society. Three committees were then appointed as follows by the chairman: Membership committee, Ted Hash, Ed Davis, Pfc. Bert Levitan, and Al Stringfellow; publicity committee, Ed Davis and Al Walker; and inspection tour committee, Al Brady and Bud Dondero.

A sound picture produced by U.S. Steel was shown at the January 25 meeting of the SOUTHERN CALIFORNIA BRANCH. The picture demonstrated the tremendous expansion that has taken place in the steel industry, and emphasized the part that U. S. Steel was taking in the "battle of production." Twenty-six members and visitors were in attendance.

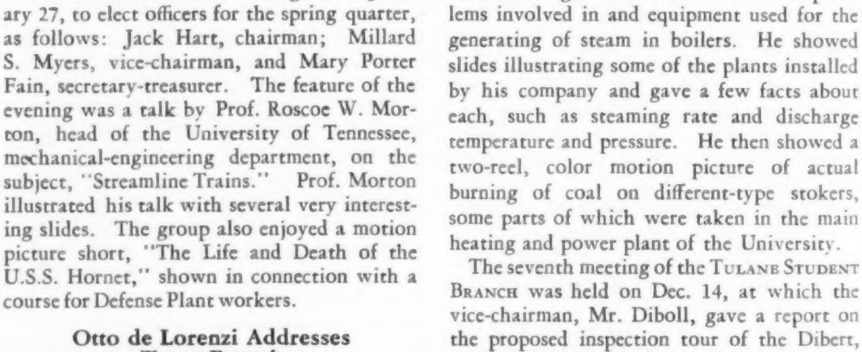
A lecture on "Fundamentals of Pressure-Cabin Operations at High Altitudes," was given by Dr. John E. Younger, head of the department of mechanical and aeronautical engineering, University of Maryland, at a joint meeting on January 24 of the TENNESSEE STUDENT BRANCH with the East Tennessee Section of the A.S.M.E. In his lecture, illustrated with slides, Dr. Younger told of his experiments at Wright Field with high-pressure cabins. He pointed out the many problems that faced the engineers when they first undertook the job of building a pressure cabin, and then told how many of these problems were solved. A brief discussion period followed Dr. Younger's comments.

The Tennessee Branch met again on January 27, to elect officers for the spring quarter, as follows: Jack Hart, chairman; Millard S. Myers, vice-chairman, and Mary Porter Fain, secretary-treasurer. The feature of the evening was a talk by Prof. Roscoe W. Morton, head of the University of Tennessee, mechanical-engineering department, on the subject, "Streamline Trains." Prof. Morton illustrated his talk with several very interesting slides. The group also enjoyed a motion picture short, "The Life and Death of the U.S.S. Hornet," shown in connection with a course for Defense Plant workers.

Otto de Lorenzi Addresses Texas Branch

The guest speaker, at a meeting on November 21 of the University of Texas Branch, was Otto de Lorenzi, director of education for Combustion Engineering Company, Inc., New York, N. Y. Mr. de Lorenzi presented an interesting discourse on some of the problems involved in and equipment used for the generating of steam in boilers. He showed slides illustrating some of the plants installed by his company and gave a few facts about each, such as steaming rate and discharge temperature and pressure. He then showed a two-reel, color motion picture of actual burning of coal on different-type stokers, some parts of which were taken in the main heating and power plant of the University.

The seventh meeting of the TULANE STUDENT BRANCH was held on Dec. 14, at which the vice-chairman, Mr. Diboll, gave a report on the proposed inspection tour of the Dibert, Bancroft, and Ross Foundry. The question of combining the various engineering societies was then brought up and favorably discussed



1943-1944 A.S.M.E. STUDENT BRANCH OFFICERS AT WORCESTER POLYTECHNIC INSTITUTE
(*Left to right:* S. B. Campbell, secretary; F. S. Moulton, president, W. C. Sturtevant, vice-president; N. S. Blodgett, treasurer.)

after which two speakers were heard. John Dabdoub gave a talk on "Some Problems of a Floating Marsh," while Arthur Grant, a graduate of Tulane University and a present employee of the Sperry Gyroscope Company of New Orleans, La., gave an interesting outline of "The Gyroscope and Its Applications."

The VIRGINIA POLYTECHNIC BRANCH held an election of officers at a meeting on December 6. The following officers were elected for a nine-month term: D. W. St. Clair, chairman; T. E. Hall, vice-chairman; Y. C. Yang, corresponding secretary; G. R. Pucci, recording secretary; H. G. Powers, treasurer, and Prof. W. J. Barber, honorary chairman.

This Branch met again on January 10, at which Prof. J. B. Jones, head of the mechanical-engineering department, explained the organization of the National A.S.M.E. and local sections as related to student branches. Two films were shown during this meeting, "Fluid Drive," and "Thrill Hunter."

Prof. Barber, honorary chairman, delivered a talk at the January 17 meeting of this Branch, and tentative plans were drawn to accept the invitation extended to Group IX, to attend the Birmingham meeting of the A.S.M.E., April 13-16. A film on "Railroading" was then presented. At the third meeting of the month held on January 24, a film entitled, "The Power Within" was shown.

WEST VIRGINIA BRANCH met on December 19 and the speakers and subjects were: W. McCoy, "Tolerance and Dimensional Control and Its Effects on the Airplane Industry;" H. G. Pyles, "Thrust Without Propellers;" R. E. Hewitt, "Boiler-Water Level Control;" P. Muffly, "Development of Timber Connections;" and H. F. Bowen, "A Lighter Age Is Coming," and "Industrial Temperature Control."

New officers were elected at a meeting of the WORCESTER BRANCH on January 13. The speaker of the evening was Mr. Howe of the Fairbanks Morse Company, Boston, Mass., whose topic was "Diesel Engines." His talk was of the general informative type, explaining the different types of Diesel engines now on the market. After his speech, Mr. Howe showed some interesting movies of the Fairbanks Morse plant.

A.S.M.E. Student Group Meetings for 1944

THE schedule for A.S.M.E. annual Student Group Meetings this spring has been modified because of war conditions. The number of Branches meeting in each group has been greatly reduced and so nearly double the number of meetings will be held. Thereby the distances to be traveled will be considerably shortened. The tentative layout is as follows:

Meeting	*Host*	*City*
Group I	Tufts College	Tufts College, Mass.
Group II	Rensselaer Polytechnic Institute	Troy, N. Y.
Group III	Cooper Union Institute of Technology	New York, N. Y.
Group IV	Lehigh University	Bethlehem, Pa.
Group V	Johns Hopkins University	Baltimore, Md.
Group VI	University of Akron	Akron, Ohio
Group VII	University of Detroit	Detroit, Mich.
Group VIII	To meet with Group XI	Chicago, Ill.
Group IX	Joining with Group X	Birmingham, Ala.
Group X	In conjunction with A.S.M.E. Spring Meeting	Birmingham, Ala.
Group XI	Illinois Institute of Technology	Chicago, Ill.
Group XII	To meet with Group XI	Chicago, Ill.
Group XIII	University of Nebraska	Lincoln, Neb.
Group IV	University of Texas	Austin, Texas
Group XV	No meeting	
Group XVI	Oregon State College	Corvallis, Oregon
Group XVII	University of Santa Clara	San Francisco, Calif.
Group XVIII	No meeting	

NOTE: Further information will be published in the April issue of MECHANICAL ENGINEERING.

Admiral Bowen Receives First Newcomen Medal

THE first award of the Newcomen Medal for achievement in steam, bestowed by The Franklin Institute of the State of Pennsylvania, was conferred in the Great Hall of The Franklin Institute, Philadelphia, Pa., Jan. 17, 1944, on Rear Admiral Harold G. Bowen, U.S.N., formerly Chief of Bureau of Engineering, Navy Department, on the occasion of the Franklin Dinner of The Newcomen Society of England, American Branch.

The citation reads as follows: "In consideration of his long record of service with a group of engineers, whose work is now such a vital part of the life of our Nation, and particularly in view of his outstanding advocacy of the advance in steam engineering in this branch of our national defense, as represented by the increase in steam pressures and temperatures used on equipment installed on its ships."

Commander Harrison Accepts for Admiral Bowen

Commander R. E. W. Harrison, U.S.N.R., member A.S.M.E., received the medal on behalf of Admiral Bowen, who was unable to be present in person.

In accepting the award on behalf of Admiral Bowen, Commander Harrison said that Admiral Bowen had often talked with him about his early struggles to secure recognition for what he believed to be so important. "Today," he said, "the steam-driven units of the U. S. Fleet, equipped with high-pressure, high-temperature steam, move from one location to another on one third less oil consumption than those of equivalent type and size of other up-to-date navies." "Furthermore," he continued, "this same remarkable economy is obtained even when the ships are tied up and only the auxiliaries are operating."

"The design," he explained, "included integral superheat boilers with economizers but not air casings. It was distinguished also from earlier designs in that the cruising or high-pressure turbine was direct-coupled and always engaged. The main gears were the new double-reduction type and a deaerated feed-water system was employed. This design represented the first time that efficient high-speed turbines with double-reduction gears and direct-coupled cruising turbines had been installed in a Naval ship. These ships represented a complete American design in all respects."

Innovations on "Somers"

"The *Somers*, contracted for in 1934, designed by Gibbs and Cox, and built by Federal Shipbuilding and Dry Dock Company, had all of these innovations together with a steam condition of 600 psi and 700 F, as well as new superheat control boilers which also incorporated a double casing within which the air necessary to support combustion was confined. This is a definite military asset in case of gas attack. As finally built, the *Somers* was operated on a steam pressure of 600 psi and 850 F, which is 369 degrees of superheat.

"As a result of the success of the *Somers*, The Bureau of Engineering raised the steam pressure on the battleships *North Carolina* and *Washington*, building at the New York and Philadelphia Navy Yards, from 700 F to 850 F. They had already been designed for 600 psi.

"In 1939, the four-stack destroyer, U.S.S. *Dahlgren*, was completely re-engined and reboilered. This ship now uses steam at 1300 psi and 925 F in the main engines, which is reported to result in a still further improvement of ten per cent in economy. While nothing has been done with this design in the past four years, it is understood that the Bureau of Ships will follow up this design in the near future, as the material situation permits.

"This is the record to date. The future is what we make it—the possibilities are boundless and progress is only limited by the degree of hard work and application which we are prepared to invest. Unfortunately, we do not live forever—the task is that of the younger men, and I believe they are trained and able to carry it along to further successes."

Stevens Research Foundation Formed for Scientific and Industrial Research

AT the annual dinner of the Alumni Association of Stevens Institute of Technology, at the Hotel Astor, New York, N. Y., Jan. 21, 1944, Harvey N. Davis, past-president A.S.M.E., president of the Institute, announced the organization of the Stevens Research Foundation, a nonprofit corporation to carry on scientific and industrial research in connection with the Institute.

Trustees Announced

The following trustees have been elected:

Harvey N. Davis, president, Stevens Institute of Technology. Robert Crooks Stanley, president International Nickel Company of Canada, Ltd., and chairman of the Board of Trustees of Stevens.

Robert Cox Post, president, Post and McCord, Inc., and chairman of the executive committee of the trustees of the college.

Willis Horr Taylor, Jr., of Pennie, Davis, Marvin, and Edmonds, and a trustee of the college.

Charles Engelhard, president, Baker and Company, Inc., and a trustee of the college.

George L. Morrison, president, General Baking Company of New York, and a trustee of the college.

James Creese, vice-president of Stevens Institute.

Dr. Davis will serve as president of the trustees of the Foundation; Mr. Post, vice-president; Mr. Taylor, secretary, and Mr. Creese, treasurer.

Foundation's Purposes

In making the announcement Dr. Davis summarized the purposes and powers of the Foundation by saying that it was empowered to receive gifts and bequests; to test and develop the public, scientific, and commercial value of inventions; to aid in obtaining patents; and to acquire property necessary for its purposes.

It was expected, he said, that the Foundation would concentrate on fundamental problems which might take several years to solve and which were of general interest and value to the public, to industry, and to government. Research would be carried out independently and in co-operation with Stevens Institute and with industries and other agencies, institutions, and organizations under definite contracts.

All present special research laboratories at Stevens, Dr. Davis continued, would be conducted by the new Foundation. Close relationship would be maintained between the College and the Foundation and their faculty and staffs—between the teaching and investigative functions, he said.

Portrait of Dr. Davis Presented

A portrait of Dr. Davis, painted by August Vincent Tack, of New York, was presented to him for the College by the Alumni during the dinner.

A.S.M.E. Calendar

of Coming Meetings

April 3–5, 1944
A.S.M.E. Spring Meeting
Birmingham, Ala.

May 8–10, 1944
A.S.M.E. Oil and Gas Power Division Meeting
Tulsa, Okla.

June 16–17, 1944
A.S.M.E. Applied Mechanics Division Meeting
Chicago, Ill.

June 19–22, 1944
A.S.M.E. Semi-Annual Meeting
Pittsburgh, Pa.

October 2–5, 1944
A.S.M.E. Fall Meeting
Cincinnati, Ohio

November 27–December 1, 1944
A.S.M.E. Annual Meeting
New York, N. Y.

(*For coming meetings of other organizations see page 40 of the advertising section of this issue*)

C. E. MacQuigg Honored

CHARLES ELLISON MACQUIGG, member A.S.M.E., dean of engineering at Ohio State University, was given the James Turner Morehead Medal of the International Acetylene Association at a dinner in his honor Monday, Jan. 24, at the Union League Club, New York, N. Y., for "advancing the oxy-acetylene processes through metallurgical research, and for leadership in welding engineering education."

The Morehead Medal is awarded annually by the International Acetylene Association in recognition of outstanding work in the acetylene industry or for advancements in the production or use of calcium carbide. The medal is awarded in honor of the late James Turner Morehead, who sponsored the experiments which led to the discovery, in 1892, of the modern electric-furnace method of producing calcium carbide, from which the acetylene industry has sprung.

Ordnance Department Needs Mechanical Engineers

ONE of the continuing problems in Ordnance for the Army is the assurance that its weapons, vehicles, and ammunition are better than the enemy's. To meet this problem the Ordnance Department is in need of mechanical engineers for service in the Technical Division in Washington or at certain of its field establishments. The work will consist of research and development projects in Ordnance and will include artillery ammunition, small-arms weapons, artillery, and all forms of combat and transport vehicles.

Sound training in technical engineering design is desirable. While experience in the development of Ordnance devices is desired, experience in the design or in production or in development of related products is essential. Such engineers must be available under Manpower Commission regulations, that is, if employed at equal skill in essential industry they should not apply.

Applications should be sent to the Central Office, U. S. Civil Service Commission, Washington 25, D. C.; attention, Mr. Newcomb in charge of Engineering Placements.

I.A.S. Elects Officers

THE Institute of the Aeronautical Sciences has announced the election of officers for the year 1944. Major R. H. Fleet of San Diego, California, was elected president. The vice-presidents are: Wellwood E. Beall, vice-president in charge of engineering of the Boeing Aircraft Company, Seattle, Washington; William K. Ebel, vice-president in charge of engineering and chief engineer, The Glenn L. Martin Company, Baltimore, Md.; Elmer A. Sperry, Jr., member A.S.M.E., vice-president, Sperry Products, Inc., New York; G. M. Williams, vice-president, Curtiss-Wright Corporation, New York; as executive vice-president, Bennett H. Horchler; as treasurer, Charles H. Colvin, member A.S.M.E., director of the Daniel Guggenheim School of Aeronautics of New York University; as secretary, Robert R. Dexter; as chairman of the council and president of the aeronautical archives, Lester D. Gardner, member A.S.M.E.

A.S.M.E. Local Sections

Coming Meetings

Anthracite-Lehigh Valley. March 24. Allentown, Pa., at 8:00 p.m. Joint meeting of Allentown and Reading districts. Subject: "Aircraft," by R. E. Brown, works manager, Allentown Division of Consolidated Vultee Aircraft Corporation. Meeting place will be announced later to members of Section.

Baltimore. March 27. Engineers' Club of Baltimore, 6 W. Fayette St., Baltimore, Md. at 8:00 p.m. Subject: "Production and Manufacturing Problems," by D. W. R. Morgan, vice-president of the A.S.M.E. and works manager, steam division, Westinghouse Electric & Manufacturing Co., Philadelphia, Pa.

Cleveland. March 6. Cleveland Engineering Society at 8:00 p.m. Joint meeting with the Machine Design Division of the Cleveland Engineering Society.

Milwaukee. March 15, 1944. Subject: New Technique in the Processing and Utilization of Wood, Particularly Plywood," by a speaker from the Forest Products Laboratory, Madison, Wis.

New London. March 15. Subject: "Welding Developments."

Providence. March 7. Providence Engineering Society at 8:00 p.m. Subject: "The Working of Magnesium," by James B. Reid, production control, magnesium division, The Dow Chemical Company.

St. Louis. March 23. Engineers' Club of St. Louis at 8:15 p.m. Joint meeting with the Engineers' Club of St. Louis. Subject:

"Engineering Materials of the Future," by A. A. Bates, manager, chemical and metallurgical section, research department, Westinghouse Electric & Manufacturing Co.

West Virginia. March 28. Daniel Boone Hotel, Charleston, W. Va., at 8:00 p.m. Preceding this there will be a dinner at 6:30 p.m. This will be a joint meeting with the American Institute of Chemical Engineers. Subject: "The Application of the Centrifugal Turbo-Compressors in the Process Industry and the Gas Turbine in the Houdry Process, and Its Possible Application as a Prime Mover," by A. E. Caudle, engineer in the blower and compressor department of the Allis Chalmers Mfg. Co., Milwaukee, Wis.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MANAGEMENT ENGINEER, 38, married. Carnegie Tech. graduate, 18 years' experience, banking, accounting, manufacturing, and sales. Desires managerial position with small or medium-sized manufacturing concern. Me-832.

ENGINEER. Construction and maintenance, desires permanent connection as plant engineer, executive assistant, or field engineer. U. S. A. or foreign, offer 22 years' experience in supervising erection of Diesel plants and industrial, marine, and chemical process equipment. Me-833.

GRADUATE MECHANICAL ENGINEER, 30. General foreman of railroad mechanical department. Seven years' experience in maintenance of steam locomotives, holding positions of machinist, assistant round-house foreman, and road foreman of engines. Desires position with eastern railroad as assistant mechanical engineer, engineer of tests, or mechanical assistant to superintendent of motive power. Me-834.

POSTWAR PLANNING mechanical engineer at present, and for 20 years employed as executive with concern manufacturing and selling hardware in position of vice-president and treasurer in charge of manufacturing, sales. Basic training engineering and sales of power-plant equipment. Position desired with company planning postwar marketing new or present products. Married. Me-835.

MECHANICAL ENGINEER, B.S. degree, age 33. Ten years' experience in heat power engineering. Now assistant professor in northern university. Desires permanent position in southwestern university. Me-836.

POSITIONS AVAILABLE

MECHANICAL ENGINEERS for aircraft engine research work. Will conduct research of all forms on power plants for airplanes and also the fuels and lubricants laboratory in which chemistry and physical chemistry are carried out on the development and perfection of fuels and lubricants, and tests of these developments are made in engines. Also need aeronautical engineers, including men having training and experience in aerodynamics. Also need electrical, chemical, civil engineers, physicists, and mathematicians. Salaries range from $3163 to $3838 a year including overtime. Ohio. W-3255D.

ENGINEERS. (*a*) Assistant project engineer, preferably graduate mechanical. Will be in charge of large group of engineers on machine layout and plant changes. Also maintain relationship with subcontractors. Should have preferably 3 to 5 years' airplane-manufacturing experience. Salary, about $5000 year. (*b*) Group engineer, mechanical, comparable to squad leader of small group of draftsmen and engineers. Should have minimum of two years' experience in airplane work. Salary, hourly basis, $1.75 to $1.90 per hour on a 60-hour week. (*c*) Liaison engineers, preferably graduate mechanical or aeronautical, although this is not necessary. Should have at least 2 years' experience in airplane industry. Need one man for shop and other for subcontracting. Hourly basis, $1.40 to $1.60 an hour. Delaware. W-3261.

ENGINEERS. (*a*) Sales engineers for industrial-instrument organization looking forward to postwar activities. Splendid opportunity for technically trained engineers, preferably with chemical or mechanical background. Nature of work requires persistence and ability to co-operate as a consultant with prospects rather than high-pressure selling. (*b*) Service engineers, not necessarily college graduates, but with some experience in industrial instruments. Boston, New York, Philadelphia, Pittsburgh, Cleveland, Milwaukee, Indianapolis, North Carolina, Kansas City, Houston, Los Angeles, and San Francisco. Headquarters Connecticut. W-3263.

ENGINEERS. (*a*) Tooling and methods man in connection with reconverting plant to peacetime operations. Salary, about $6000 year. (*b*) Engineer to take charge of contract terminations. Will involve the handling of terminated contracts upon which the company is prime contractor, and handling the claims of its subcontractor. Must know something about contract law and accounting as well as shop practice. Salary, minimum of $4000 year. Ohio. W-3272D.

ENGINEER to handle contract terminations for company engaged in manufacture of high-pressure valves. Salary about $7000–$8000 year. Ohio. W-3273.

INDUSTRIAL ENGINEERS with considerable experience in planning, processing, controls, wage incentive, etc. Prefer man who has had some paper or paint manufacturing experience. Salary open. Permanent. New York metropolitan area. W-3302.

TOOL ENGINEER with several years' experience in tool and die work. Will work under supervision for large manufacturing company engaged in postwar work. $4500 a year. Permanent. Massachusetts. W-3309.

TIME-STUDY MAN. Must have some machine-shop background. $4000–$4500 a year. Permanent. Long Island, N. Y. W-3315.

ENGINEERS. (*a*) Development and design engineer, 35–50, electrical, on small transformers up to 2 kw. Should be experienced in power, audio and radio frequencies. Will later assist and advise in the manufacture. Permanent. $7500–$10,000 a year. (*b*) Senior electrical engineer experienced in radar manufacture. Salary open. Massachusetts. W-3325E.

PRODUCTION ENGINEER. Must be able to assume full responsibility for putting new product into manufacture. Should have had experience on small-parts manufacture and assembly. Salary open. Permanent. New York, N. Y. W-3351B.

PRODUCTION ENGINEER for medium-sized progressive gage-manufacturing company. Must be well acquainted with small precise parts manufacture and assembly. Must be fully acquainted with modern production methods and capable of assuming full charge of production, planning, scheduling, etc. Permanent postwar opportunity. Salary open. New England. W-3354.

ENGINEER, experienced, to head up drafting division. Should be good tool designer and practical shop man able to design tooling for manufacture of small hand tools and make corrections in product and to correlate engineering with current production. Essential activity with excellent postwar prospects. Will have charge of four or five draftsmen. About $4800 year. Upper N. Y. State W-3363.

TOOL DESIGNER, MACHINE DESIGNER, AND DESIGN ENGINEER. Mechanical designing jobs existing both in engineering tool-design department and development engineering department. Salaries to $6000 a year for top-notch project engineer capable in product or machine design. Ohio. W-3375D.

MECHANICAL DRAFTSMAN to design mechanical-electrical pressure instruments. Should have had some experience on diaphragm or bellows type units. Permanent. $4000–$5000 year. New Jersey. W-3387.

ENGINEERS. (*a*) Engineer to be assistant de-

[1] All men listed hold some form of A.S.M.E. membership.

partment head in product-analysis department. Must have had prevous production experience in mass production of precision parts. About $4000 a year. (*b*) Engineer to be assistant department head in product-analysis department. Must have had previous production experience in mass production of precision parts. About $4000 year. (*c*) Engineer to work on general assignment in production-control department. About $3000 year. New York State. W-3389.

Shop Superintendent for small machine shop. Should be practical-minded individual, preferably who has worked on machines and will be able to direct labor as well as supervise design for plant. Although company is now doing war work, this position will continue during postwar period. About $5000 a year plus bonus. Pennsylvania. W-3391.

Graduate Mechanical Engineer to work in design department on checking of prints. Should have knowledge of machine-shop practice. Work will be mostly in connection with small-gear operations. Company manufactures precise instruments. $5500–$6500 year. New York, N. Y. W-3398.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after March 25, 1944, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

Allen, C. Malcolm, Columbus, Ohio
Bastian, Alvin L., Akron, Ohio
Beyster, Henry E., Detroit, Mich.
Birdsong, John M., Schenectady, N. Y. (Rt & T)
Boddy, Fredk. A., Detroit, Mich. (Rt)
Bowers, Roscoe H., New Orleans, La.
Bowman, John C., Austin, Texas
Brenner, Julian, East Orange, N. J.
Cabrera, J. M., Mexico City, D.F., Mexas
Canavan, H. M., Cincinnati, Ohio
Chapman, R. E., Toronto, Ont., Canada
Cheney, Lloyd T., East Cleveland, Ohio
Choporis, Peter N., Detroit, Mich.
Cochran, J. Richard, Council Bluffs, Iowa
Colburn, A. P., Newark, Del.
Cole H. M. (Capt.), Detroit, Mich.
Cooledge, M. M., New York, N. Y.
Cooper, Frank S., Jr., Charleston, W. Va.
Dawson, Melville D., Kirkwood, Mo.
De Gray, Wm. G., Rochester, N. Y.
De Shazer, Grant A., Washington, D. C. (Rt & T)
Dinges, R. M., Forest Hills, N. Y.
Donnelly, L. F. (Ensign), Buffalo, N. Y.
Eddie, Chas. E. S., Wyandotte, Mich.
Ely, Robt. G., Newark, N. J. (Rt & T)
Farmer, Geo. C., Chicago, Ill.
Fearnside, Thos. A., Wellesley, Mass.
Fielder, H. S., Evanston, Ill.
Foster, Francis E., Providence, R. I.
Frankenhoff, A. G., New York, N. Y.
Grant, Ray M., Chicago, Ill.
Gray, H. A., Red Bank, N. J.
Green, Luther S., Jr., Cynwyd, Pa.
Gubitose, Nicholas F., Berwick, Pa.
Hamil, Jas. K., Westport, Conn.
Harrison, F. H., Tennyson, South Australia
Havens, Louis A., Valley Stream, N. Y.
Hoff, Nicholas J., Brooklyn, N. Y.
Hoover, Harmer G., Brooklyn, N. Y.
Hopper, J. O., Bakersfield, Calif.
Hubbard, E. R., Teaneck, N. J.
Judge, J. Emmet, Bronxville, N. Y.
Kearney, O'Earl, Brookline, Mass.
Klekotka, J. A., Villanova, Pa.
Kuehn, Howard E., Stonington, Conn.
Kux, Andrew, Minneapolis, Minn.
Kyle, Peter E., Cambridge, Mass.
La France, Raymond, Cleveland, Ohio
Lelgemann, William, Reading, Pa.
Lennie, A. M., Midland, Mich.
Lindau, J. W., 3rd, Columbia, S. C.
MacKenzie, J. B., Erie, Pa.
Manas, Vincent T., Washington, D. C. (Rt)
Mattimore, John D., Louisville, Ky.
McClintock, Frank A., Hartford, Conn.
McCort, J. E., Cleveland, Ohio
McKaig, Alvin W., Phila., Pa. (Rt)
McLarren, Robt., New York, N. Y.
Miller, Sherman N., Schenectady, N. Y.
Mills, David L., Maywood, Ill.
Moeller, H. G., Chicago, Ill.
Moore, Coleman B., Philadelphia, Pa.
Moore, Howard A., Flint, Mich. (Re)
Motherwell, G. W., Worcester, Mass.
Munn, Hugh F., Albuquerque, New Mex.
Nelidov, Ivan M., Sacramento, Calif.
Nemeth, Otto R., Chicago, Ill.
Nichols, Louis A., Jr., Bellefonte, Pa.
Odom, Guy T., Evansville, Ind.
Packman, Ian B., Syracuse, N. Y.
Parcels, C. F., Louisville, Ky.
Parker, Darrell Smith, Westfield, N. J.
Pinger, Geo. C., Bronxville, N. Y. (Rt)
Platt, Barney S., Detroit, Mich.
Redfield, John A., Monroe Center, Conn.
Robertson, Robt. J., Victoria, Australia
Robinson, Watson V., Phila., Pa.
Rodgers, Walter A., Baldwin, N. Y.
Roessler, Edw. W., Bloomfield, N. J.
Rose, R. G., Victoria, Australia
Ruisi, N. John, Flushing, N. Y. (Rt & T)
Schachnow, Abraham S., Detroit, Mich.
Schmidt, Alfred O., Milwaukee, Wis.
Schubert, Julius, Brooklyn, N. Y.
Sebo, E. Geo., New York, N. Y.
Shafer, A. H., Pittsburgh, Pa.
Singleton, Philip A., Everett, Mass.
Stead, Henry G., London, Ont., Canada
Steel, Ned H., Dallas, Texas
Steurer, Geo. E., Dayton, Ohio
Stoeckly, E. E., Marblehead, Mass.
Tetzel, Fred B., Louisville, Ky.
Thoenebe, H. S., Oreland, Pa. (Rt)
Voorhees, Guy A., Indianapolis, Ind. (Rt)
Wadleck, Jos. P., Buffalo, N. Y.
Wallach, Bernard H., New York, N. Y.
Wells, J. Arthur (Lieut.), New York, N. Y.
Wempe, Robt. H., Curundu, Canal Zone
Whistler, A. M., Alhambra, Calif.
Whittaker, Harry L., Long Beach, Calif.
Wickman, L. F., Oakland, Calif.
Wilkins, Harry F., Lafayette, Ill.
Yerk, Henry H., New York, N. Y.

CHANGE OF GRADING

Transfer to Fellow

DuboscLard, Paul, Buffalo, N. Y.
Guy, H. L., London, England

Transfers to Member

Anderson, Edwin L., Verona, N. J.
Black, Alex. R., New York, N. Y.
Brink, W. E., Seattle, Wash.
Fetscher, John J., New York, N. Y.
McConathy, Donald R., Flushing, N. Y.
Raub, J. Heartt, Waterbury, Conn.
Wellauer, Edw. J., Milwaukee, Wis.

Necrology

THE deaths of the following members have recently been reported to headquarters:

Cameron, Edward H., August 13, 1943
Challender, Ralph T., December 6, 1943
Chapman, Kenneth B., February 9, 1943
Clemens, Wilson F., July, 1943
Durban, Thomas E., January 5, 1944
Frost, Edward J., January, 1944
Gibling, Harold F., December 10, 1943
Goetze, Frederick, January 30, 1944
Lindsay, Alexander, November 16, 1943
Mayo, William Benson, January 31, 1944
Meston, Charles Robert, October 4, 1943
Miro, Rudolph M., August 18, 1943*
Mullins, Edward E., November 30, 1943
Reed, E. Howard, December 26, 1943

* Died in line of duty.

A.S.M.E. Transactions for February, 1944

THE February, 1944, issue of the Transactions of the A.S.M.E. contains:

Boiler Embrittlement, by C. A. Zapffe
A Sampling Inspection Plan for Continuous Production, by H. F. Dodge
Physical Properties of a Structural Plastic Material, by C. W. Armstrong
Isothermal Pressure Drop for Two-Phase Two-Component Flow in a Horizontal Pipe, by R. C. Martinelli, L. M. K. Boelter, T. H. M. Taylor, E. G. Thomsen, and E. H. Morrin
The Differential Shrinkage of Wood, by W. L. Greenhill
Problems of Construction and Alternate Substitutions in Wood Aircraft, by J. M. Stevens